ATLAS AND HAND BOOK

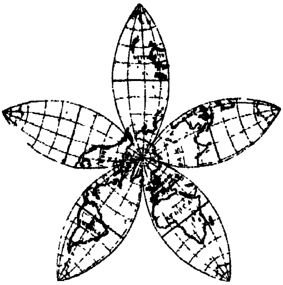
OF

PHYSICAL GEOGRAPHY

From

ORIGINAL AND AUTHENTIC MATERIALS

With analytical Indexes.



BY

KEITH JOHNSTON JUNR.

F. R. G. S.

W. & A. K. JOHNSTON,
EDINBURGH & LONDON.

Sta. Hall

Price 6.

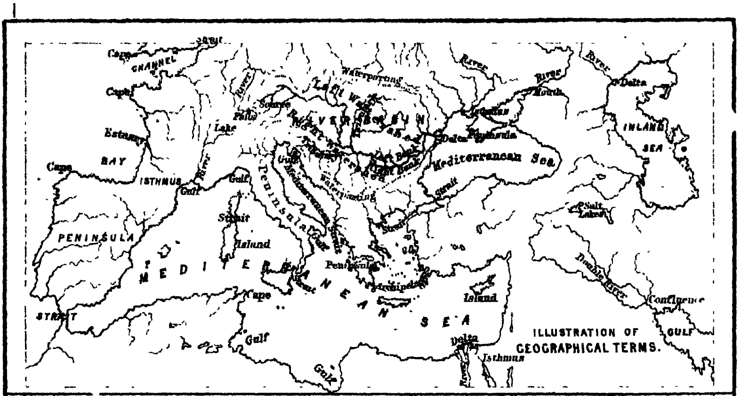
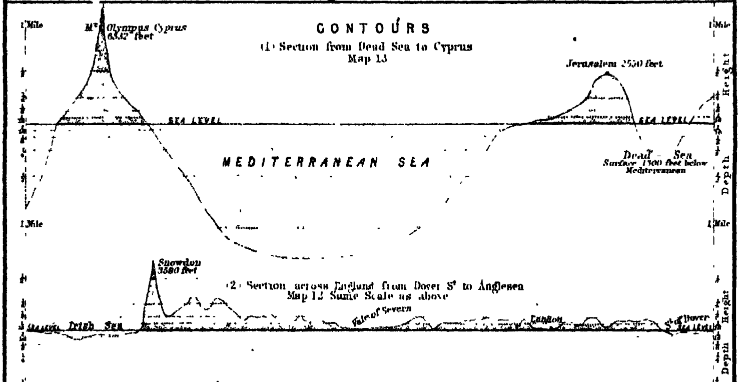


ILLUSTRATION OF GEOGRAPHICAL TERMS.

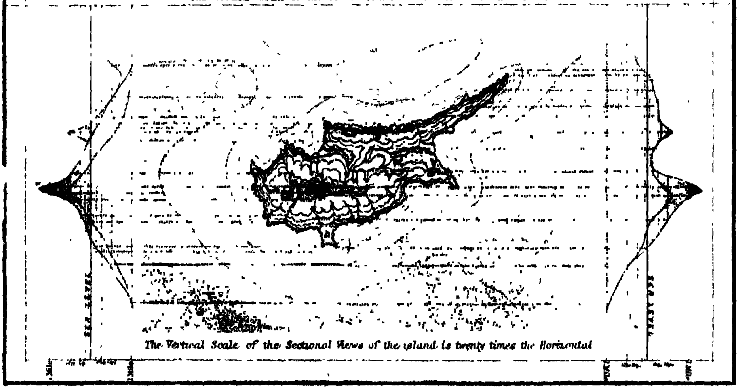
CONTOURS

(1) Section from Dead Sea to Cyprus
Map 13



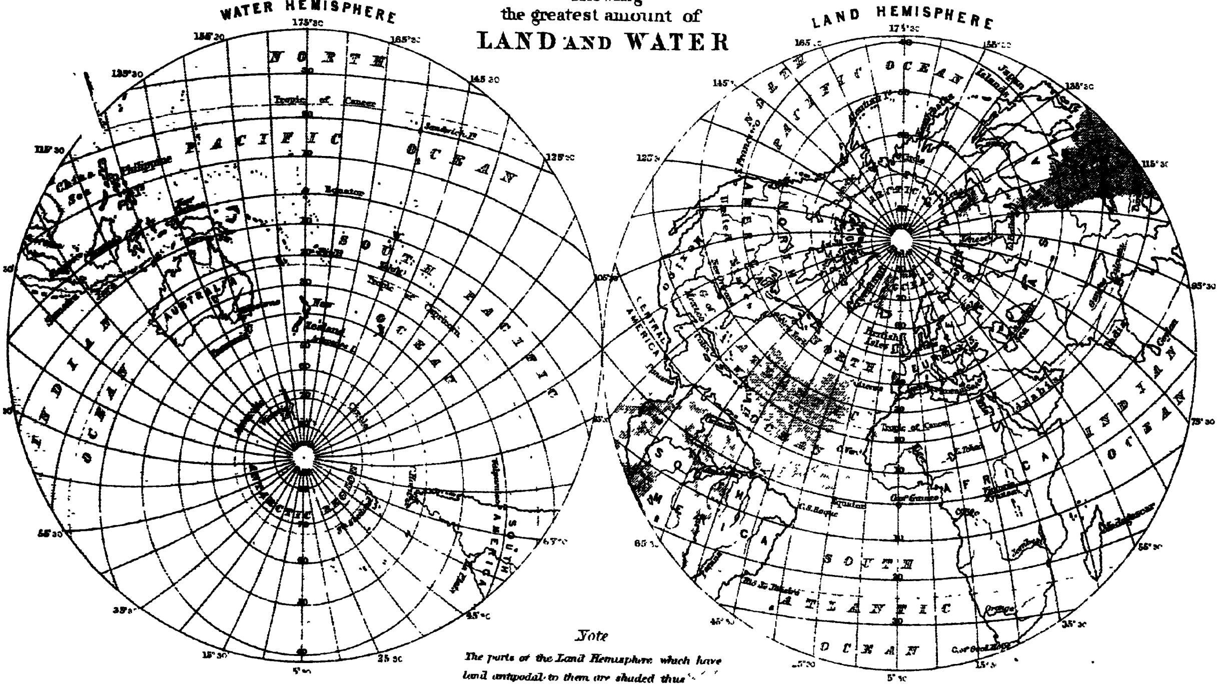
(2) Section across England from Dover St to Anglesea
Map 12 Same Scale as above

The Vertical Scale of the above Sections is fifty times the Horizontal



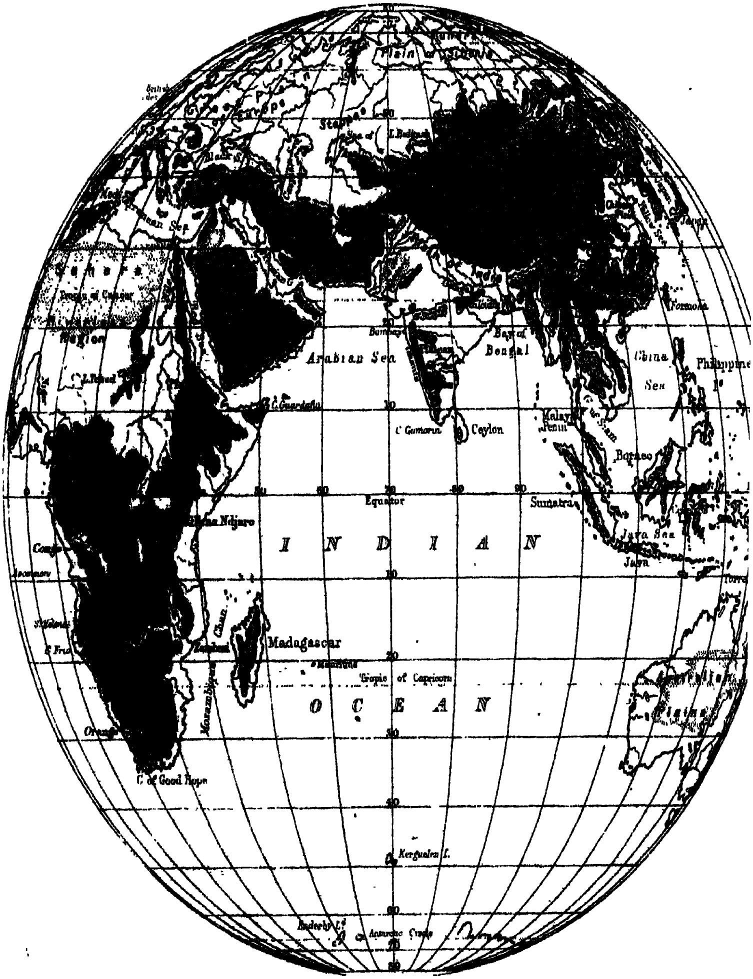
The Vertical Scale of the Sectional Views of the island is twenty times the Horizontal

HEMISPHERES
showing
the greatest amount of
LAND AND WATER



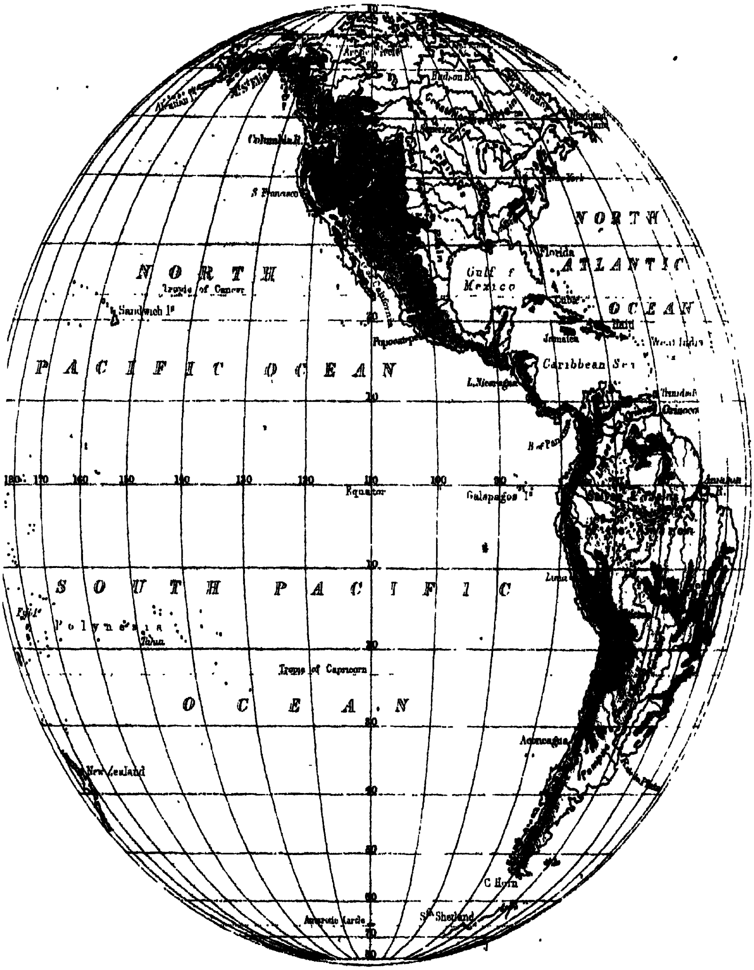
Note
The parts of the Land Hemisphere which have land antipodal to them are shaded thus

A PERSPECTIV



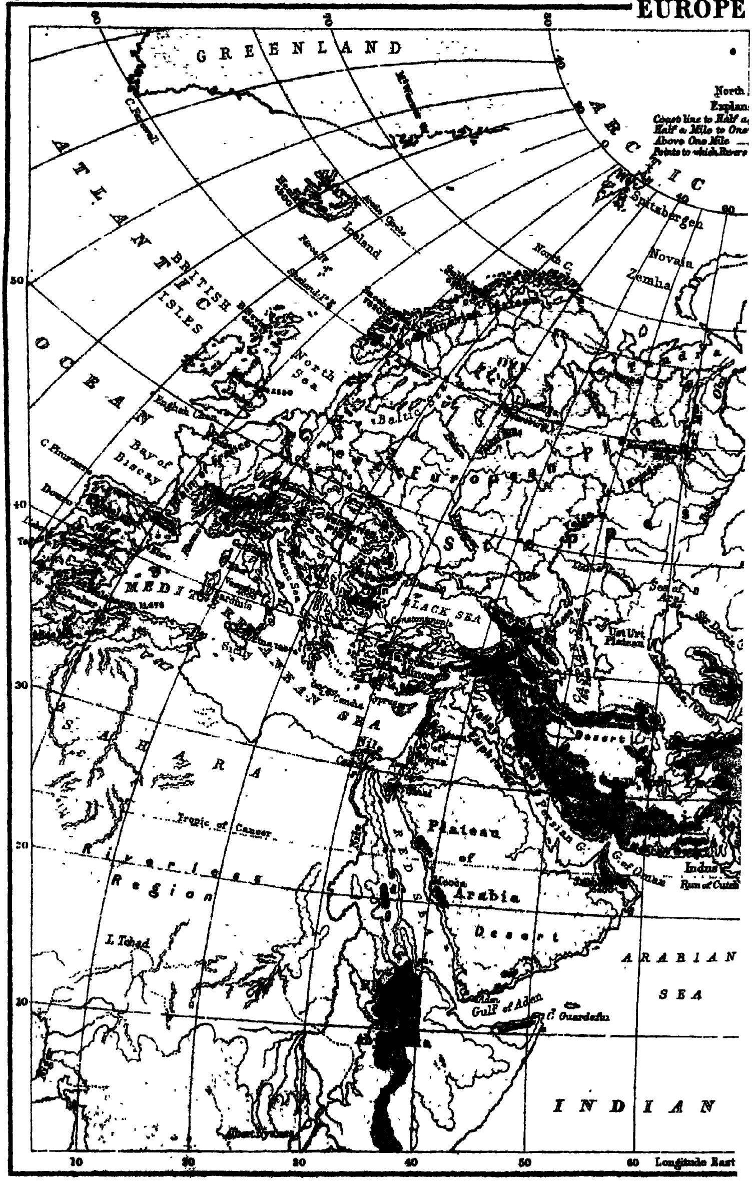
W & A.K. Johns

IEW OF THE GLOBE



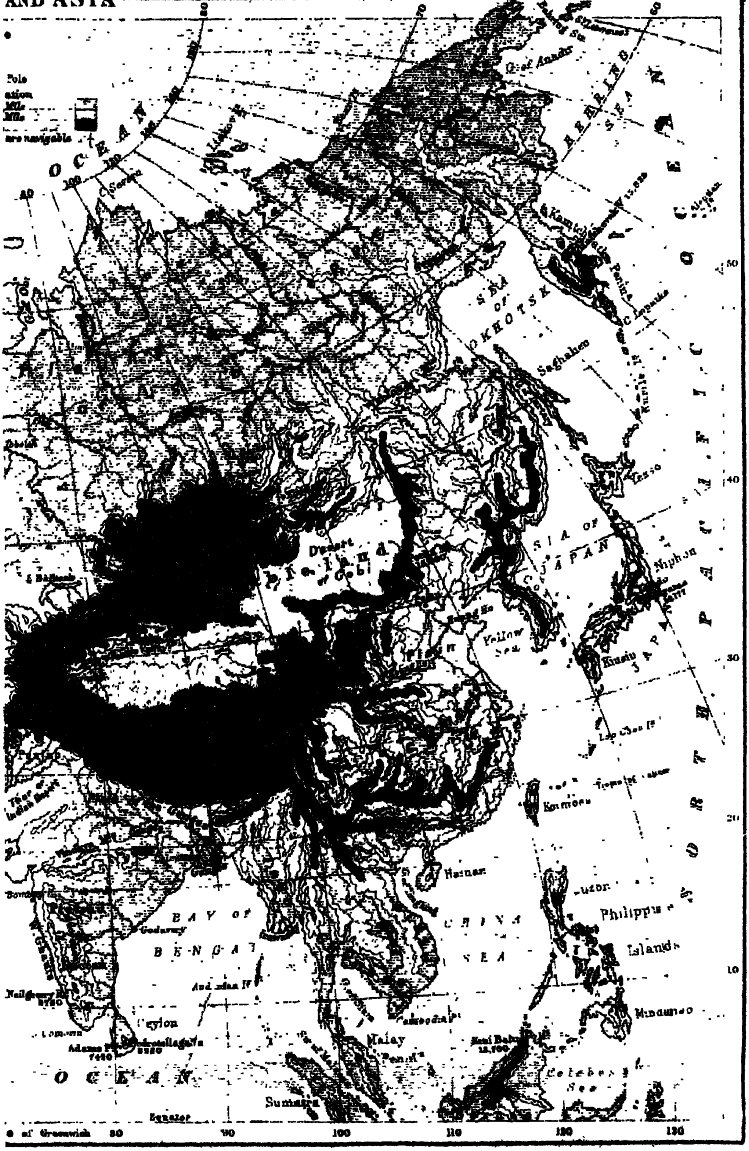
Edinburgh, and London

EUROPE



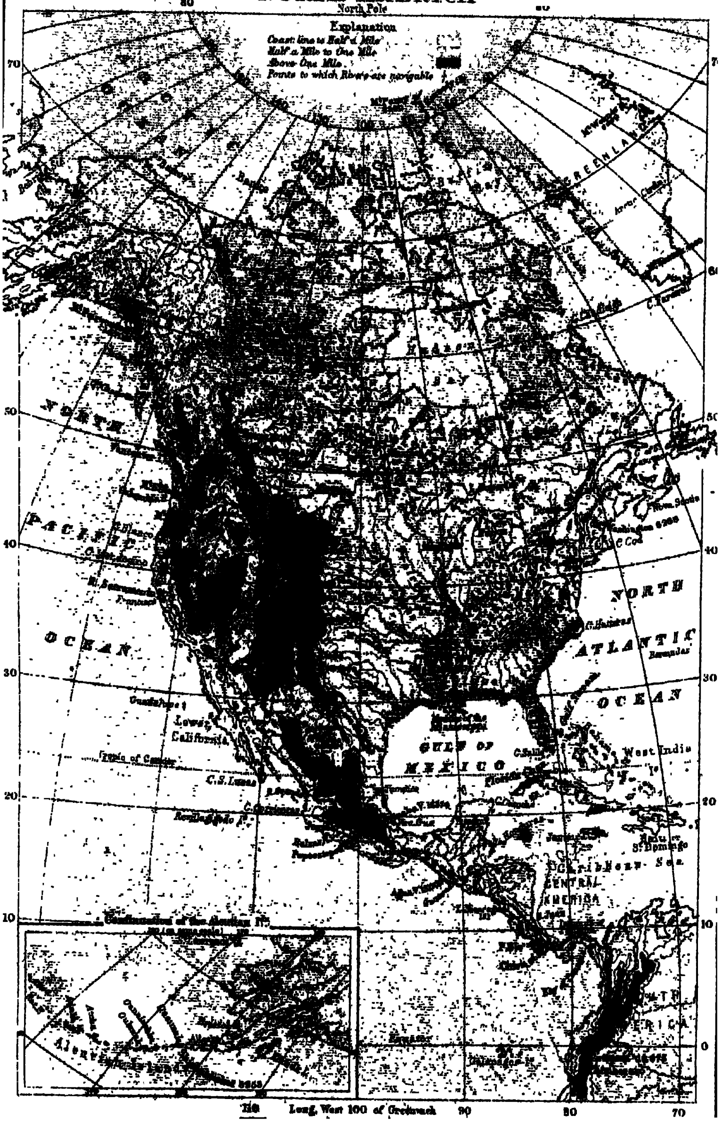
W & A K Johnston

AND ASIA



Edinburgh and London

NORTH AMERICA



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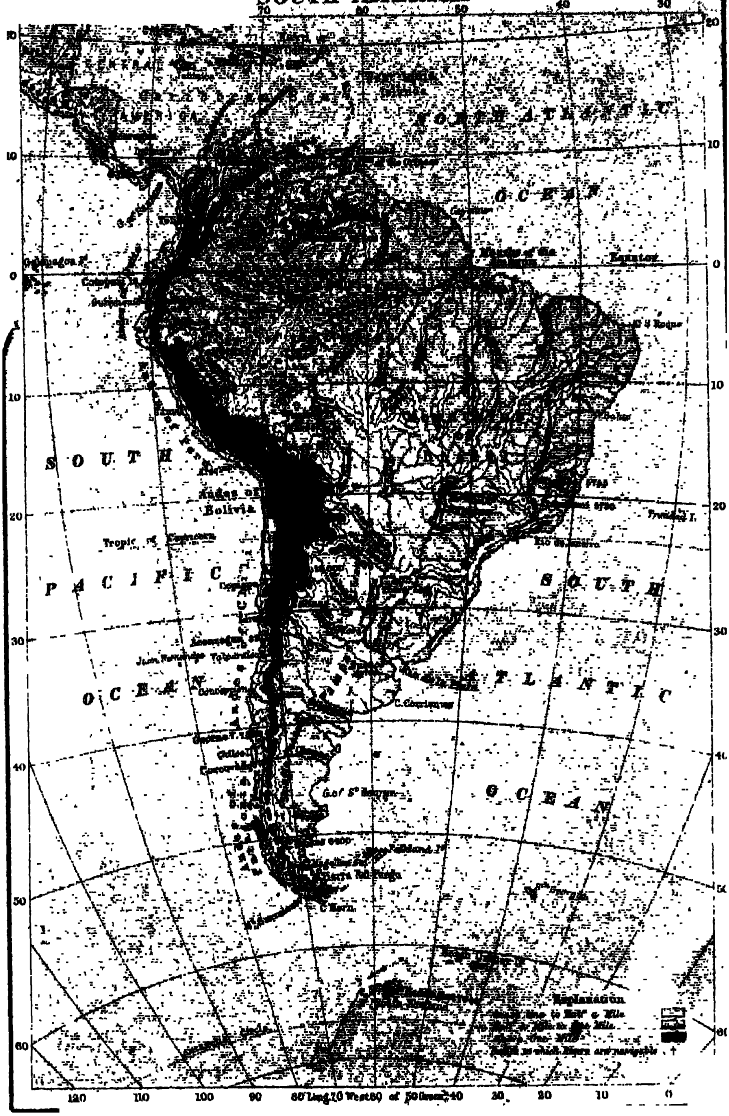
SOUTH AMERICA



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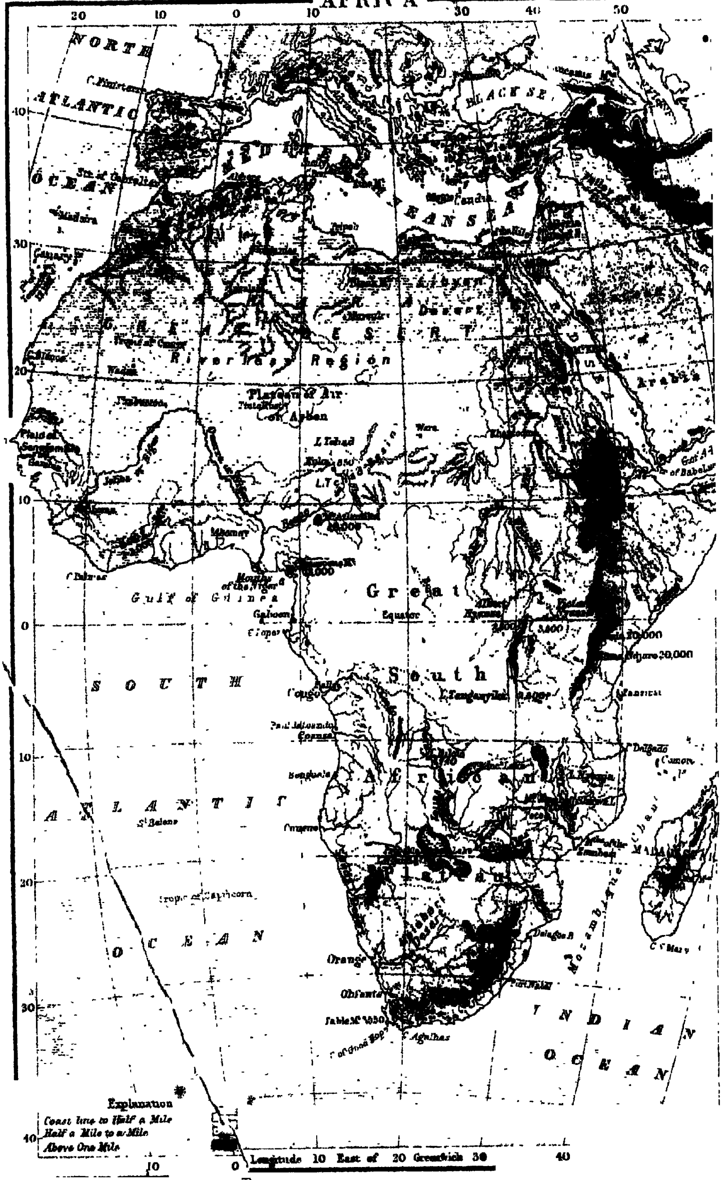
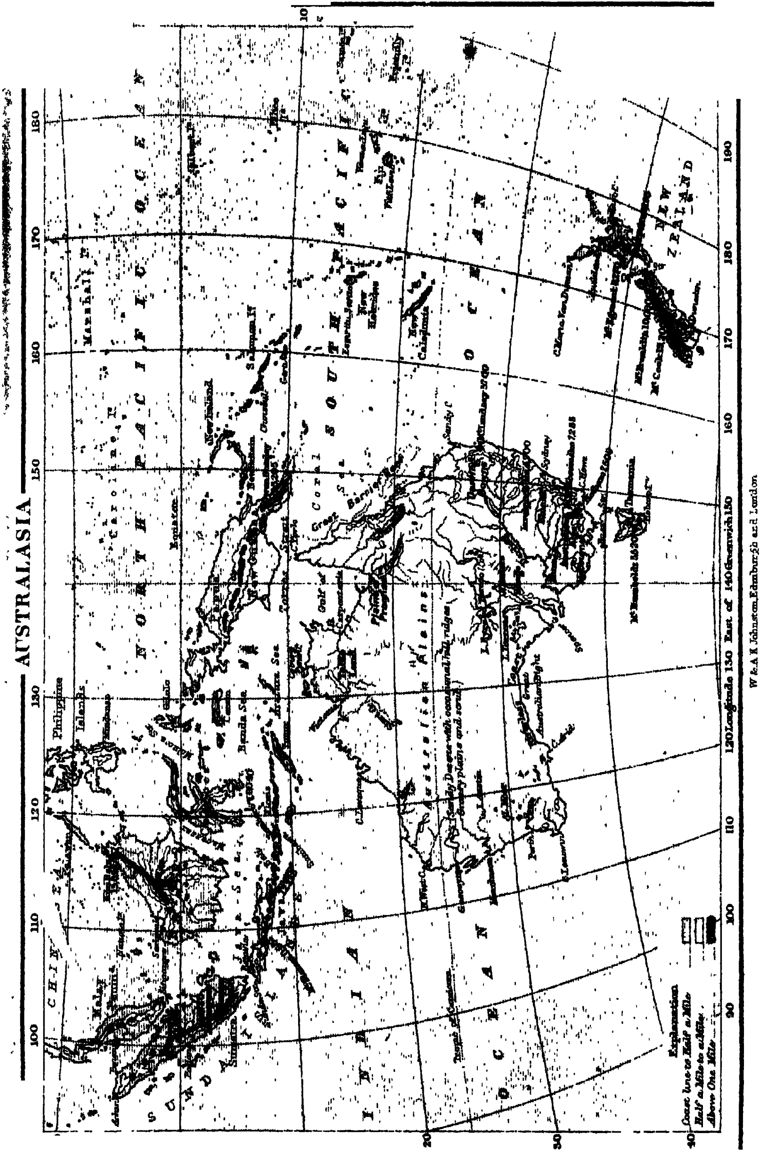
9

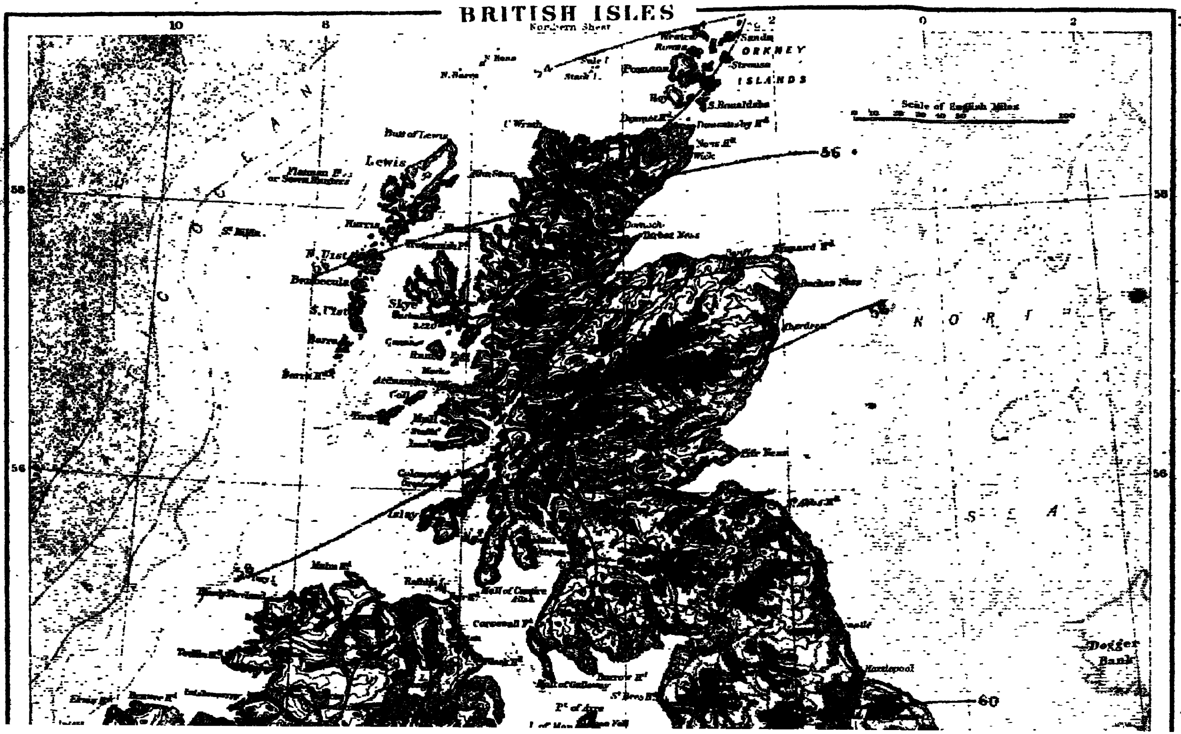
AFRICA

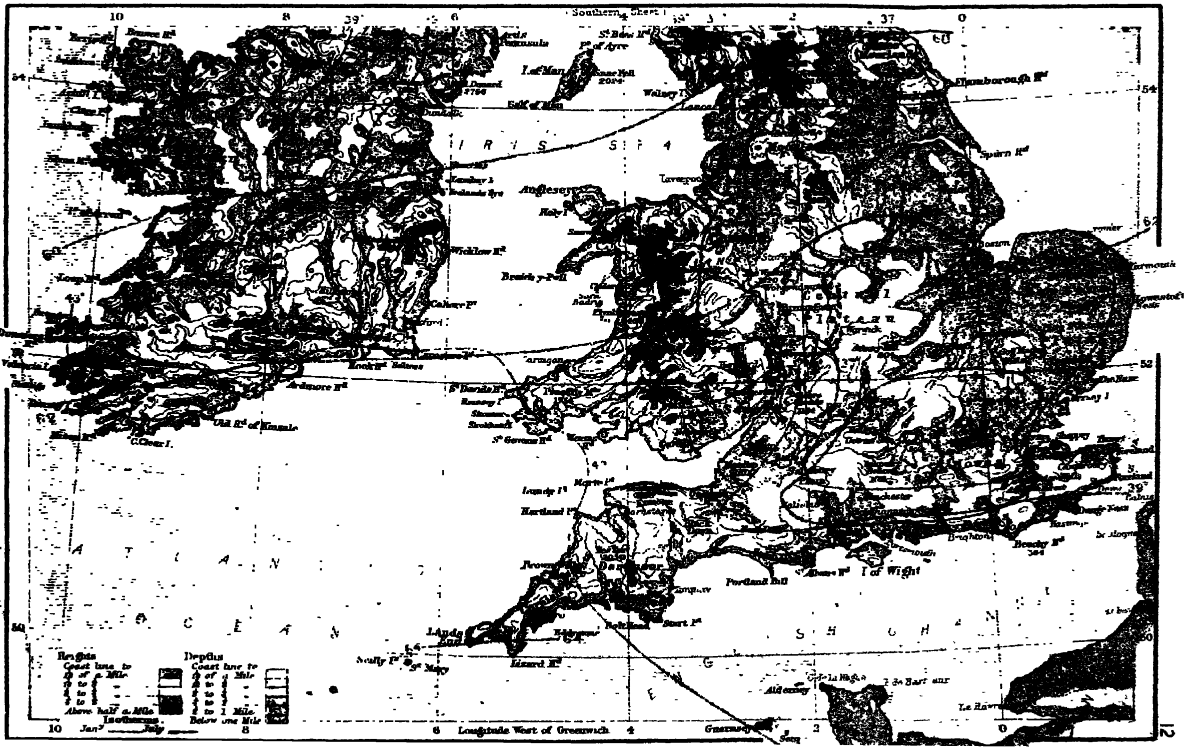


20
10
0
10
30
40
50
NORTH
C. Finisterre
ATLANTIC
OCEAN
Str. of Gibraltar
Madeira I.
Canary Is.
MEDITERRANEAN SEA
Candia
BLACK SEA
Caucasus Mts.
Algiers
Tripoli
Libyan Desert
SAHARA DESERT
River Less Region
C. Blanco
Plateau of Air
Ahaggar
C. Verde
Senegambia
L. Tchad
Wara
Khartoum
Gulf of Aden
Str. of Babel Mandeb
Arabia
Niger
Mouths of the Niger
Cameroons Mt.
C. Palmas
Gulf of Guinea
Gaboon
C. Lopez
Great
Equator
Albert Nyanza
Victoria Nyanza
Kenia 20,000
Kilimanjaro 20,000
South
Congo
L. Tanganyika
Zanzibar
San Paul de Loanda
Benguela
African
L. Nyassa
C. Delgado
Comoro Is.
SOUTH
ATLANTIC
St. Helena
Zambesi
Mozambique Channel
MADAGASCAR
Tropic of Capricorn
OCEAN
Orange
Kalahari Desert
Delagoa B.
C. St. Mary
Olifants
Port Natal
Table Mt. 3550
C. of Good Hope
C. Agulhas
INDIAN
OCEAN
Explanation
Coast line to Half a Mile
Half a Mile to a Mile
Above One Mile
Longitude 10 East of 20 Greenwich 30
40
10
0


AUSTRALASIA
Philippine Islands
Mindanao
Celebes
Borneo
Sumatra
Malay
Banda Sea
Arafura Sea
Timor
Torres Strait
New Guinea
New Ireland
Solomon Is.
Caroline Is.
Marshall Is.
Gilbert Is.
New Hebrides
New Caledonia
Fiji Is.
N O R T H   P A C I F I C   O C E A N
S O U T H   P A C I F I C   O C E A N
I N D I A N   O C E A N
S U N D A   I S L A N D S
Coral Sea
Great Barrier Reef
Gulf of Carpentaria
Great Australian Bight
Sydney
Perth
C. Leeuwin
Tasmania
N E W   Z E A L A N D
Tropic of Capricorn
Explanation
Coast line to Half a Mile
Half a Mile to a Mile
Above One Mile
100
110
120
130
140
150
160
170
180
10
20
30
40
120 Longitude 130 East of 140 Greenwich 150
W & A K Johnston, Edinburgh and London

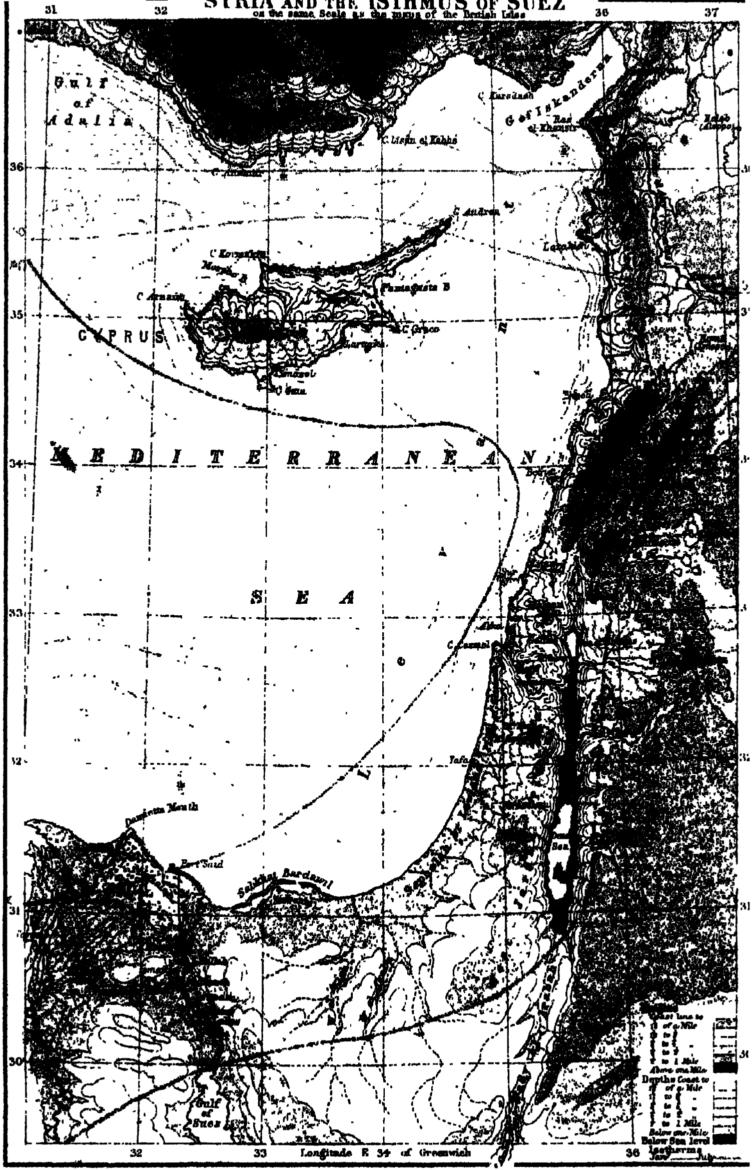
BRITISH ISLES




Southern Sheet
10
8
39°
6
4
3
2
37
0
54
52
50
I of Man
Snae Fell 2024
Pt of Ayre
St Bees Hd
Calf of Man
Walney I.
I R I S H   S E A
Flamborough Hd
Spurn Hd
Liverpool
Anglesey
Holy I
Dundalk
Lambay I.
Wicklow Hd
Carnsore Pt
Hook Hd
Ardmore Hd
Old Hd of Kinsale
C.Clear I.
Mizen Hd
Valencia I.
Loop Hd
Achill I.
Brandon Hd
Braich y Pwll
Cardigan
St Davids Hd
Ramsey I
Skomer
Skokholm
St Govans Hd
Yarmouth
Lowestoft Ness
The Naze
Sheppey
N. Foreland
S. Foreland
Dover
Calais
Dunge Ness
Beachy Hd
Brighton
St Albans Hd
I of Wight
Portland Bill
Start Pt
Bolt Head
Eddystone
Lizard Hd
Lands End
Scilly Is
St Mary
Lundy Is
Hartland Pt
Morte Pt
Dartmoor
Salisbury
Winchester
Alderney
Guernsey
Sark
C. de la Hague
Le Havre
A T L A N T I C   O C E A N
E N G L I S H   C H A N N E L
Heights
Coast line to
of a Mile
to
to
to
Above half a Mile
Isotherms
Jany
July
Depths
Coast line to
of a Mile
to
to
to
to 1 Mile
Below one Mile
Longitude West of Greenwich

SYRIA AND THE ISTHMUS OF SUEZ

on the same Scale as the maps of the British Isles



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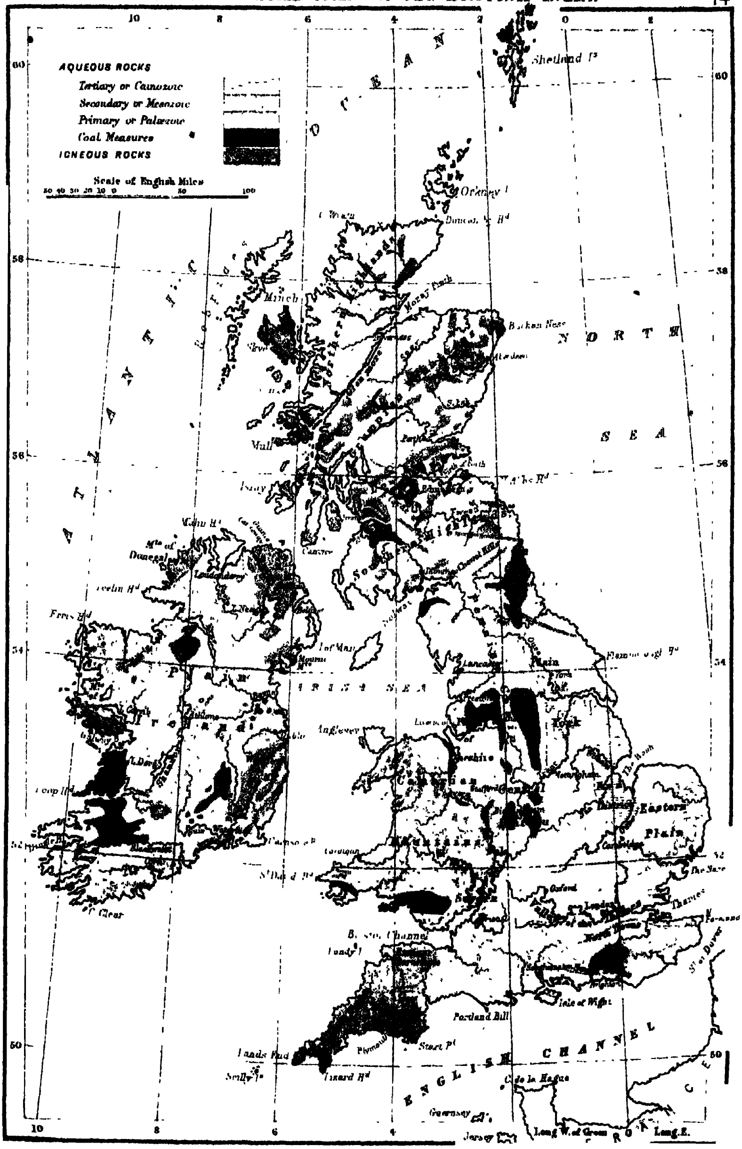
A GEOLOGICAL MAP OF THE BRITISH ISLES



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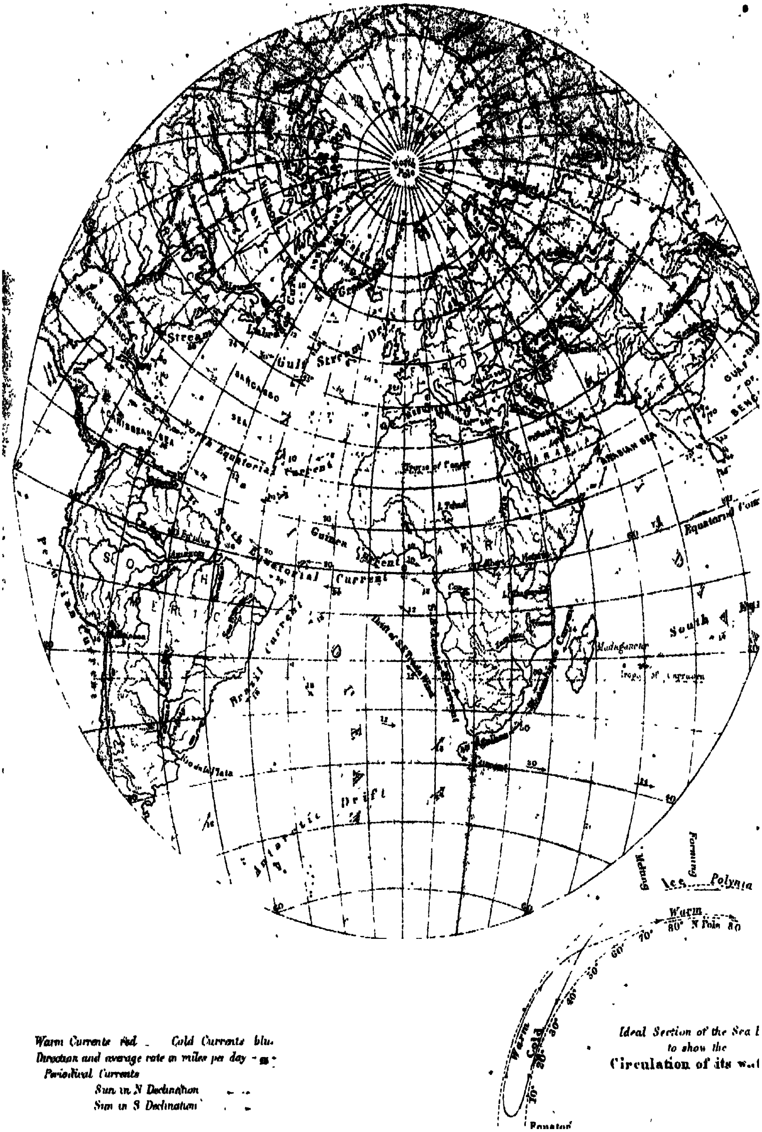
]

OCEAN CURRENT



Warm Currents red _ Cold Currents blu
Direction and average rate in miles per day
Periodical Currents
Sun in N Declination
Sun in S Declination

Ideal Section of the Sea
to show the
Circulation of its w

RIVER SYSTEMS

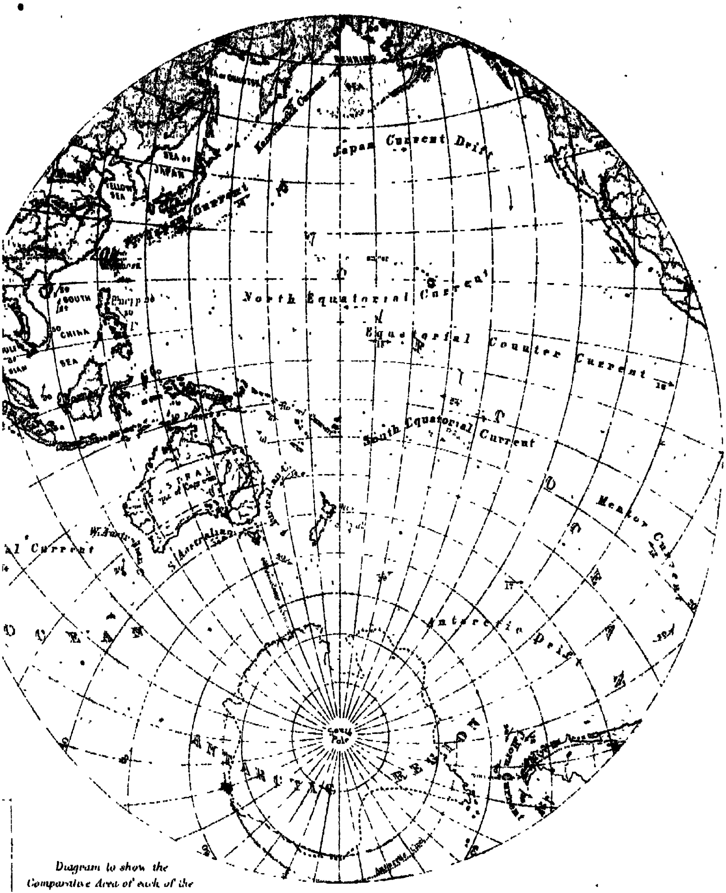
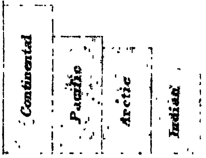
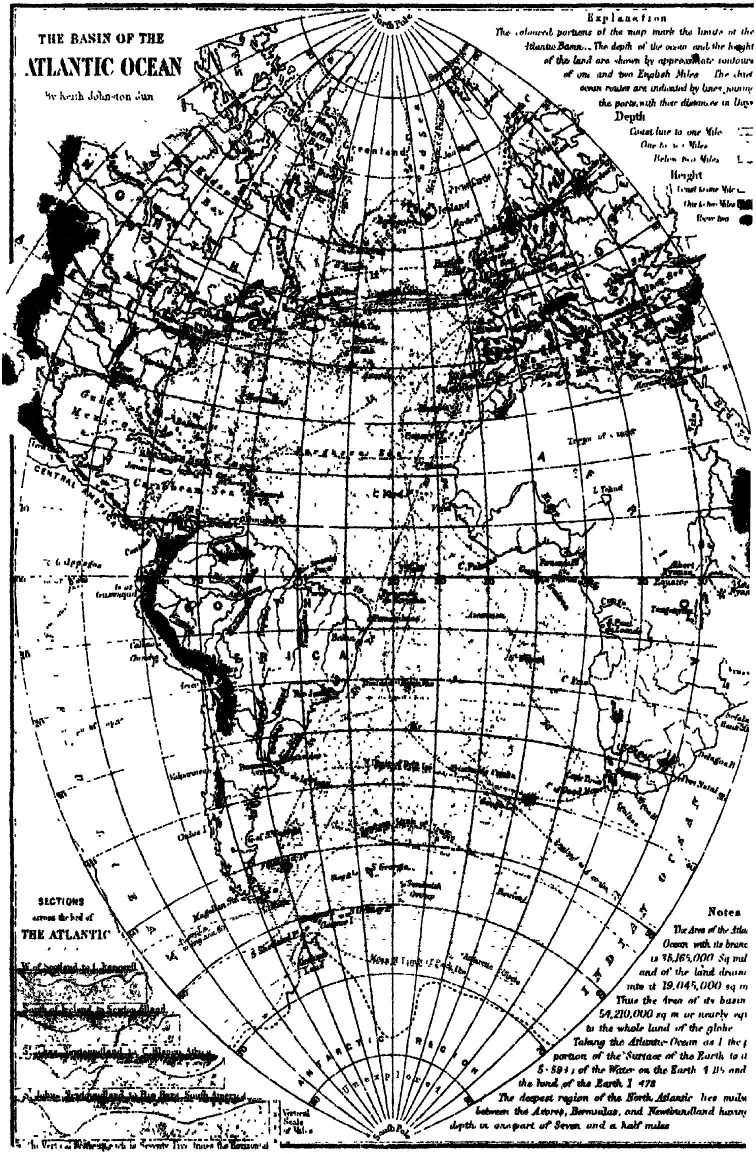


Diagram to show the Comparative Area of each of the River Systems



The land draining to the various Oceans is coloured thus, Atlantic, yellow; Pacific, purple; Arctic and Indian Oceans, green. The boundaries of the Oceans are indicated in the same colour. Areas of Continental drainage are coloured brown.

ugh and London



THE BASIN OF THE

ATLANTIC OCEAN

by Keith Johnston Jun

Explanation

The coloured portions of the map mark the limits of the Atlantic Basin.. The depth of the ocean and the height of the land are shown by approximate contours of one and two English Miles. The chief ocean routes are indicated by lines joining the ports, with their distances in Days

Depth

Coast line to one Mile

One to two Miles

Below two Miles

Height

Coast to one Mile

One to two Miles

Above two

SECTIONS

across the bed of

THE ATLANTIC

The Vertical Scale is Seventy Five times the Horizontal

Notes

The Area of the Atla

Ocean with its branc

is 35,165,000 Sq mil

and of the land drain

into it 19,045,000 sq m

Thus the Area of its basin

54,210,000 sq m or nearly equ

to the whole land of the globe

Taking the Atlantic Ocean as 1 the p

portion of the Surface of the Earth to it

5·594; of the Water on the Earth 4·115 and

the land of the Earth 1·478

The deepest region of the North Atlantic lies midw

between the Azores, Bermudas, and Newfoundland having

depth in one part of Seven and a half miles

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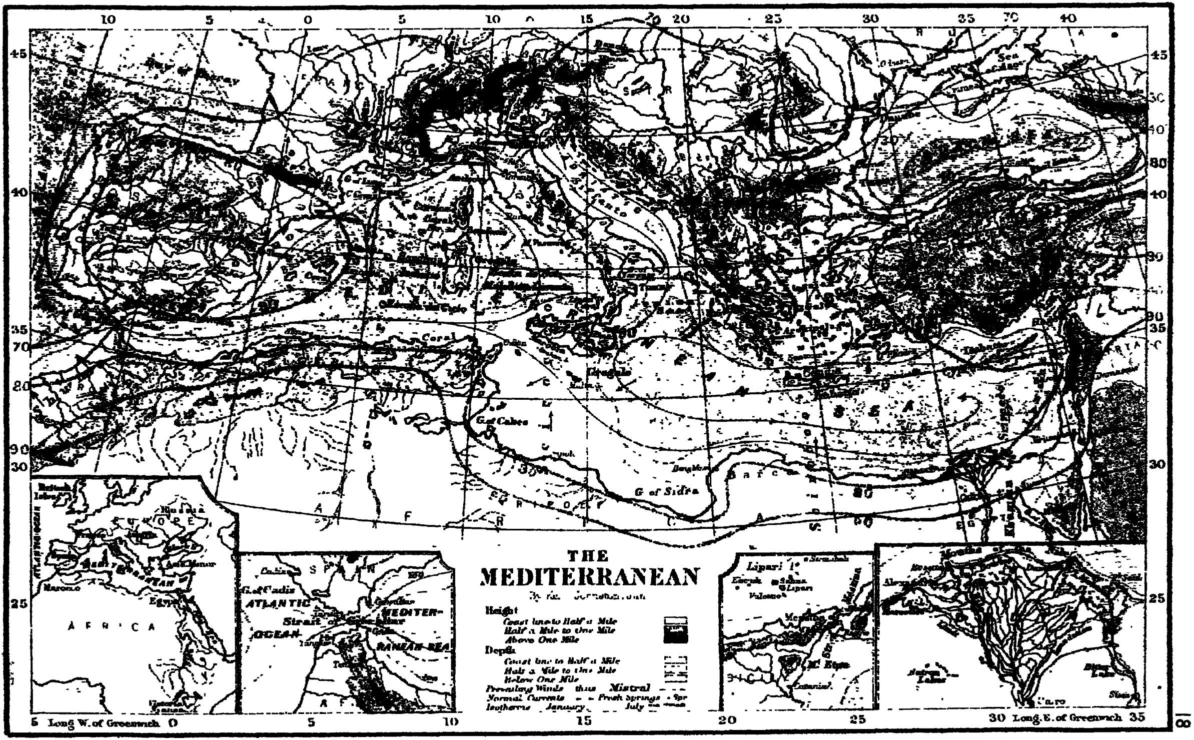
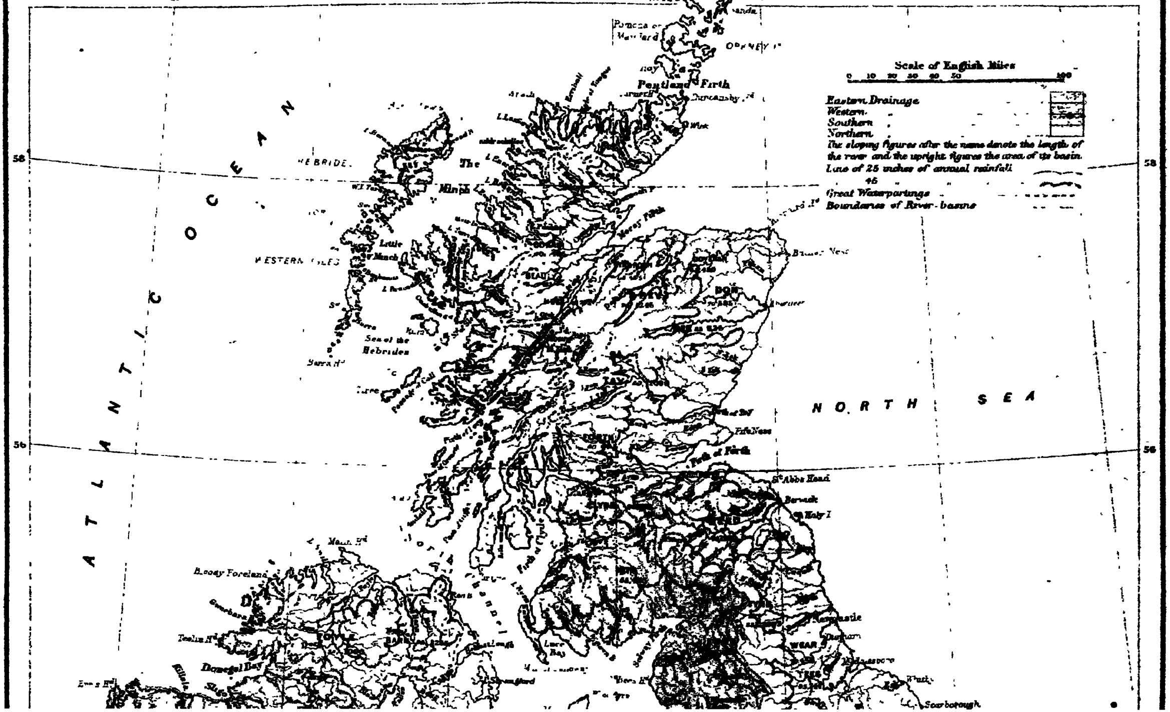
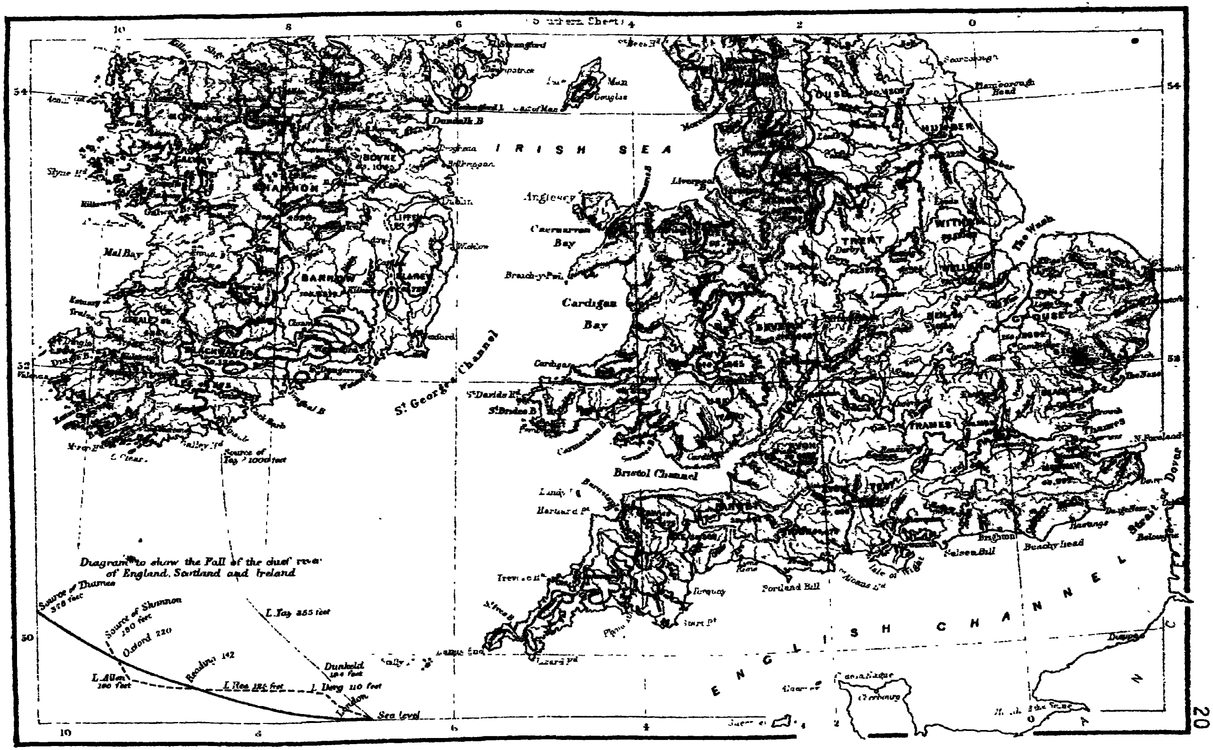


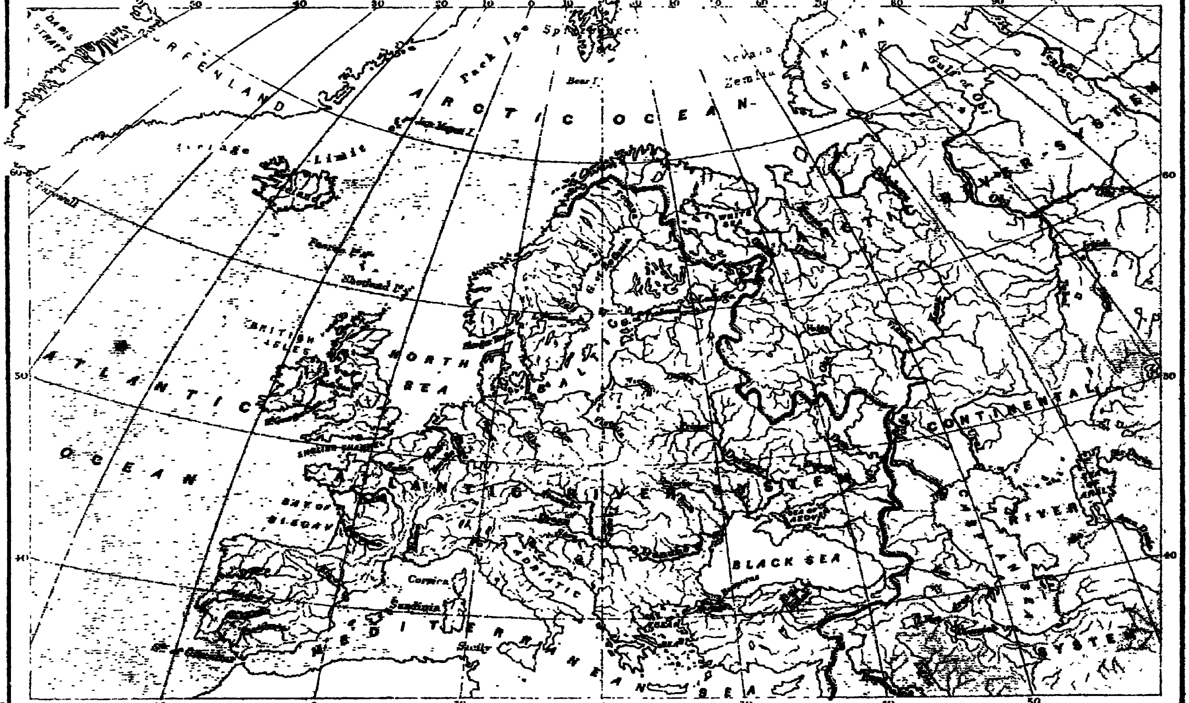
THE
MEDITERRANEAN
Height
Coast line to Half a Mile
Half a Mile to One Mile
Above One Mile
Depth
Coast line to Half a Mile
Half a Mile to One Mile
Below One Mile
Prevailing Winds thus Mistral
Normal Currents
Fresh Springs
Isotherms January
July
Long W. of Greenwich
Long E. of Greenwich
Bay of Biscay
G. of Cabes
G. of Sidra
Coral
Sea
ATLANTIC
OCEAN
Strait of Gibraltar
MEDITERRANEAN SEA
G. of Cadiz
Cadiz
SPAIN
Tangier
Gibraltar
EUROPE
AFRICA
Egypt
Asia Minor
Marocco
British Isles
Lipari Is.
Stromboli
Salina
Lipari
Vulcano
Messina
Mt Etna
Catania
Cairo
Suez
Bitter Lake

THE RIVER SYSTEMS OF THE
BRITISH ISLES
(Northern Sheet)




Southern Sheet
IRISH SEA
ST GEORGE'S CHANNEL
ENGLISH CHANNEL
Bristol Channel
Cardigan Bay
Caernarvon Bay
Anglesey
Man
Douglas
Liverpool
Dublin
Wicklow
Wexford
Drogheda
Dundalk B
Strangford
Mal Bay
Slyne Hd
C. Clear
St Davids Hd
St Brides B
Lundy I
Hartland Pt
Portland Bill
Torquay
Start Pt
Lizard Pd
Lands End
Scilly Is
Isle of Wight
Selsea Bill
Brighton
Beachy head
Hastings
Dover
Straits of Dover
N. Foreland
Boulogne
Dieppe
Cherbourg
The Wash
Flamborough Head
Scarborough
SHANNON
BOYNE
BARROW
TRENT
THAMES
HUMBER
OUSE
WITHAM
WELLAND
Diagram to show the Fall of the chief rivers of England, Scotland and Ireland
Source of Thames 376 feet
Source of Shannon 280 feet
Oxford 220
Reading 142
London
Sea level
L. Allen 160 feet
L. Ree 126 feet
L. Derg 110 feet
L. Tay 355 feet
Dunkeld 184 feet
Source of Tay 1000 feet
54
52
50
10
8
6
4
2
0

THE RIVER SYSTEMS OF EUROPE



The Areas of the River Basins and Systems are given in the Notes.

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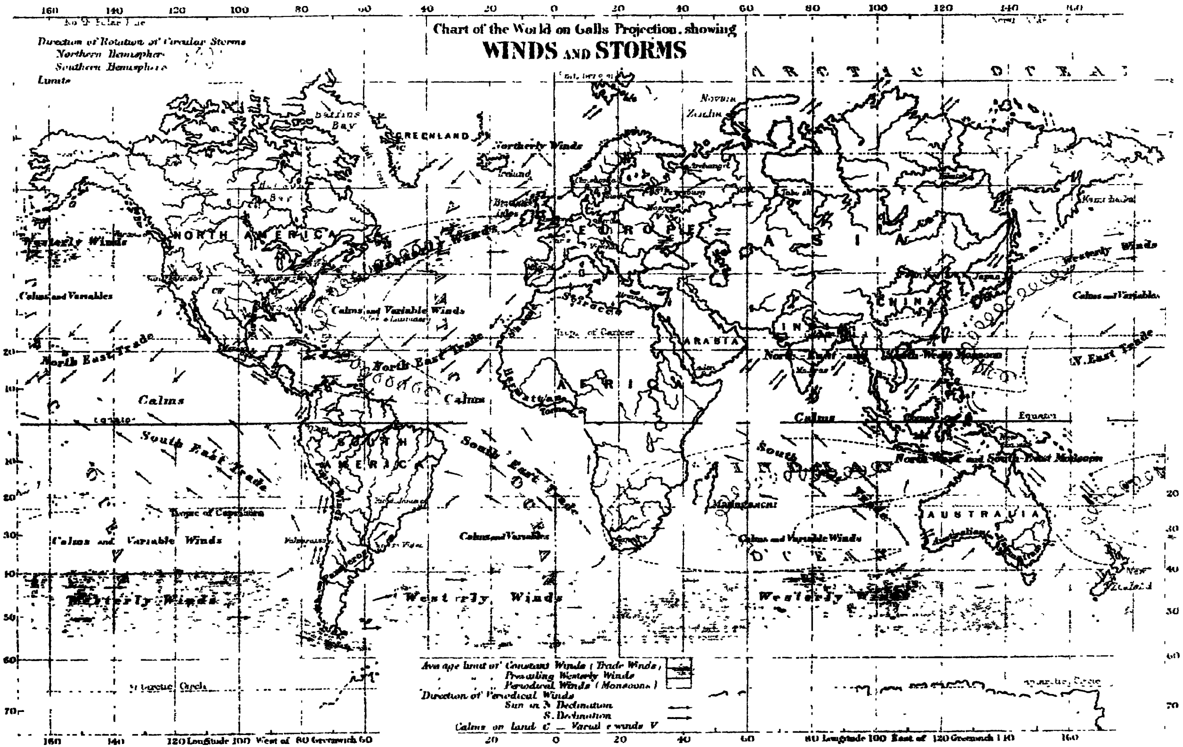
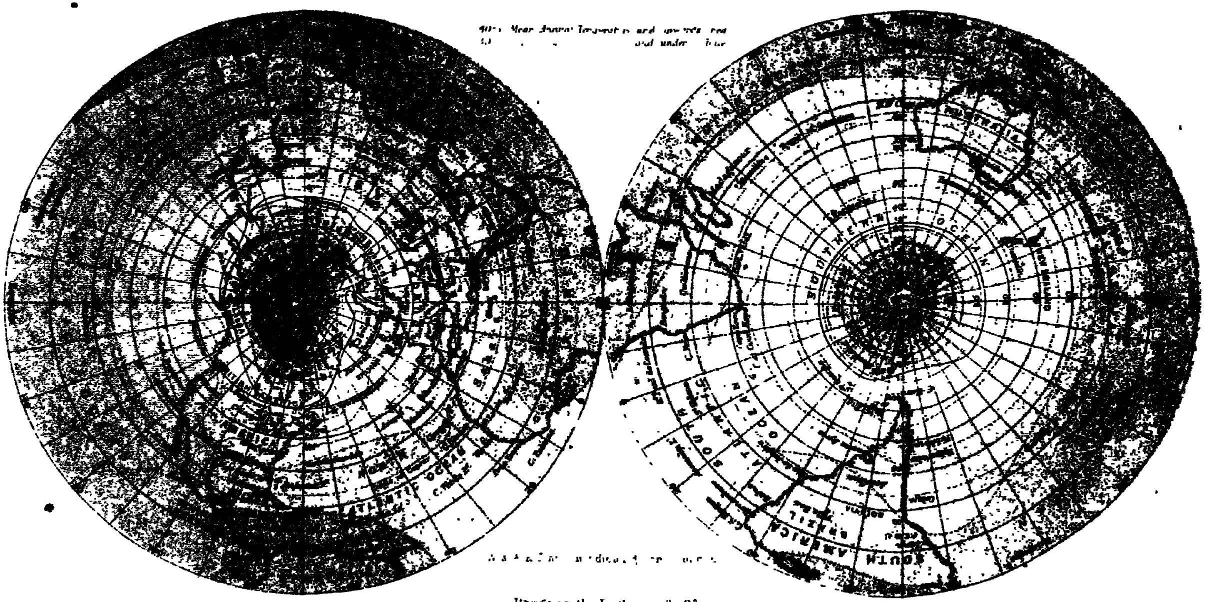


Chart of the World on Galls Projection, showing

WINDS AND STORMS

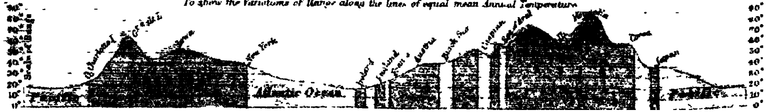
ANNUAL ISOTHERMAL LINES



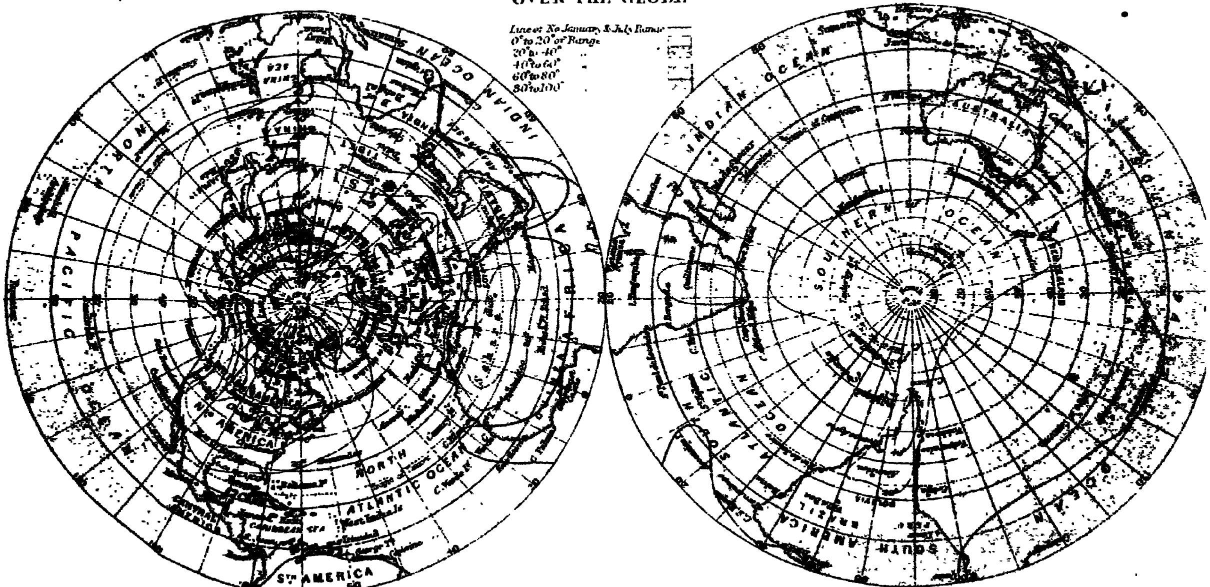
[illegible]

Range on the Isotherm of 50°

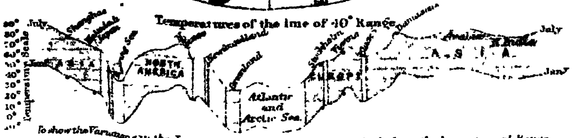
To show the Variations of Range along the lines of equal mean Annual Temperature



OVER THE GLOBE

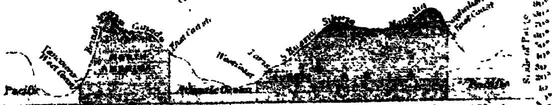


Temperatures of the line of 40° Range



To show the Variations in the January and July temperatures which form the lines of equal Range

Range on the Parallel of 50° N Lat.

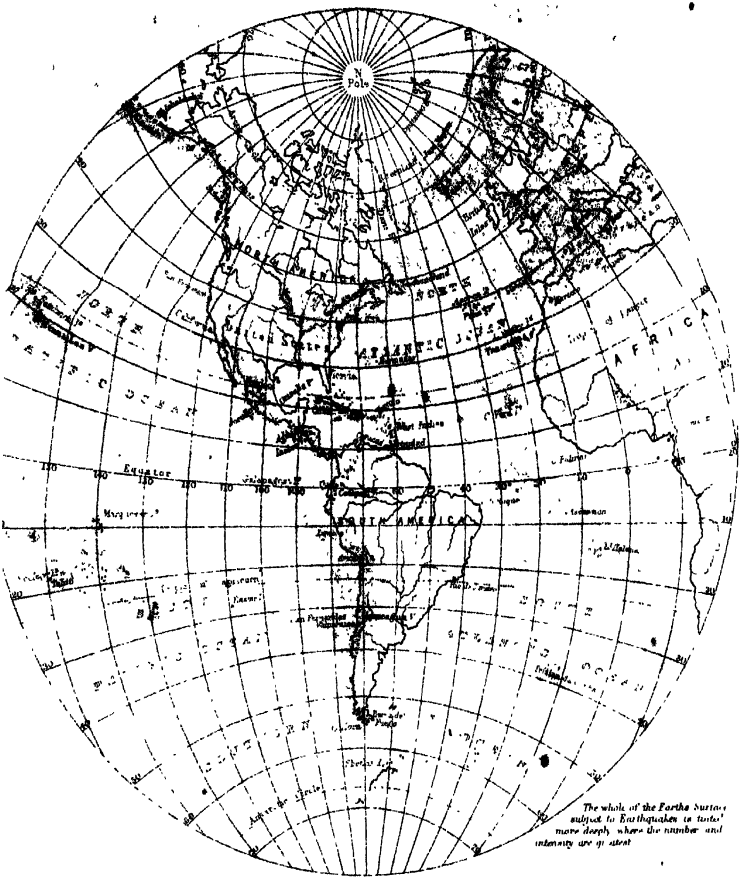


To show the Variations of Range in the same Latitude and the difference of Range on East and West Coasts

24

GEOGRAPHICAL DISTRIBUTION OF

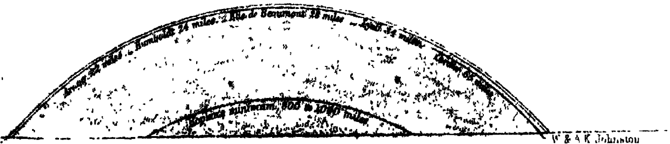
according to



The whole of the Earths Surface subject to Earthquakes is tinted more deeply where the number and intensity are greatest

Diagram showing the probable thickness of

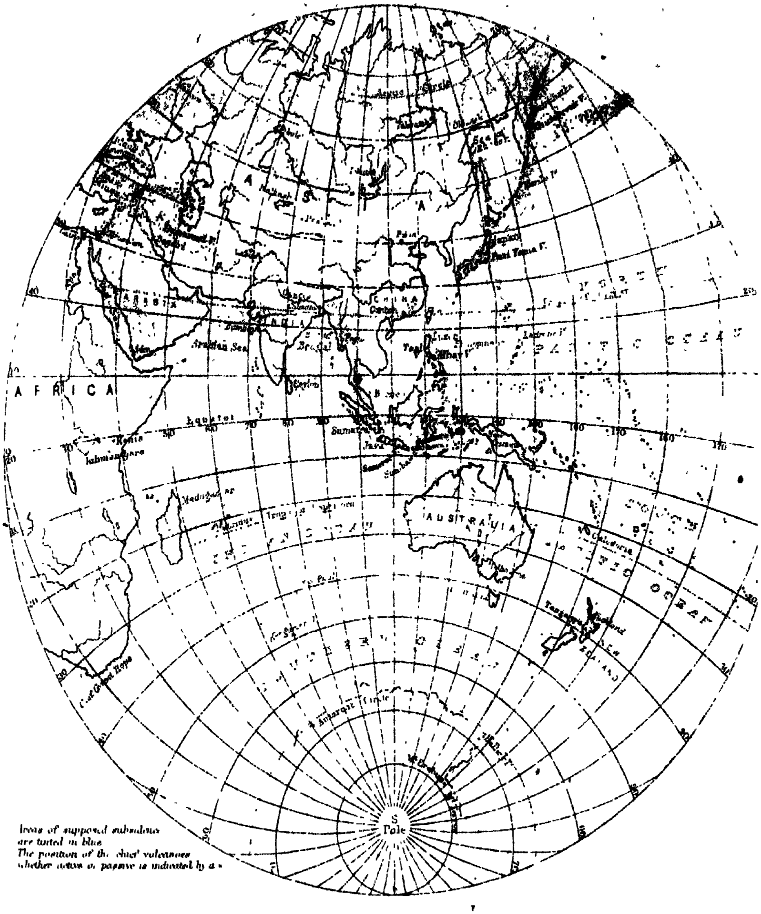
THE EARTH'S CRUST



W & A K Johnston

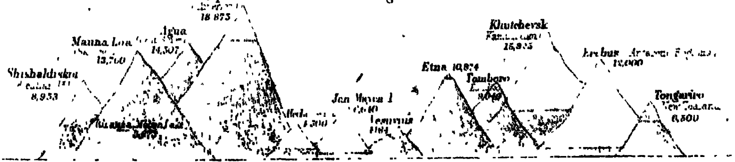
EARTHQUAKES AND VOLCANOES

R. and J. Mallet



Areas of supposed subsidence are tinted in blue
The position of the chief volcanoes whether active or passive is indicated by a •

GROUP OF THE CHIEF ACTIVE VOLCANOES in each region

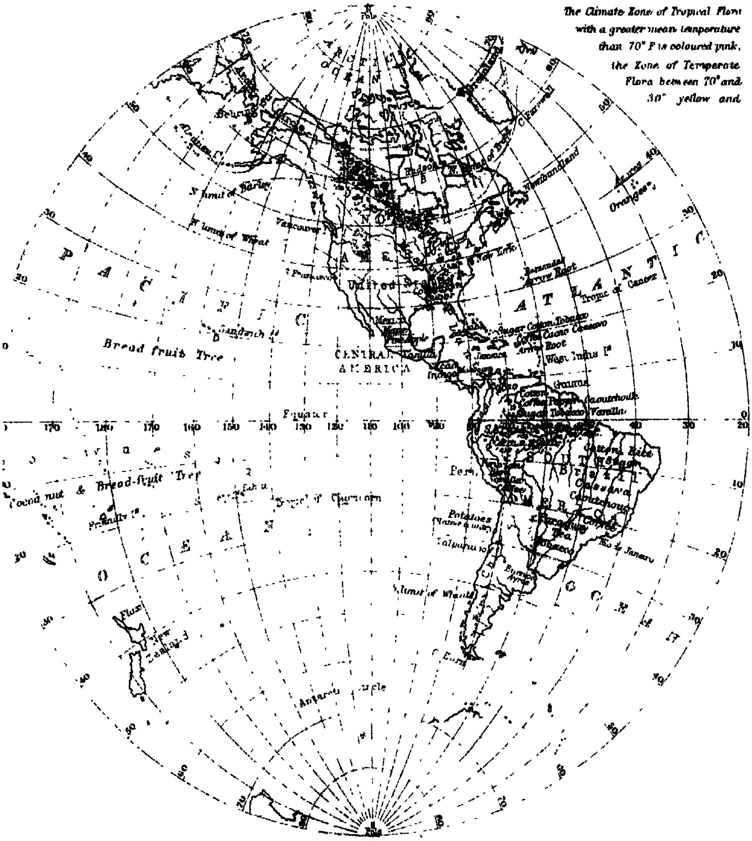


Edinburgh and London

GEOGRAPHICAL

OF SOME OF THE CHIEF

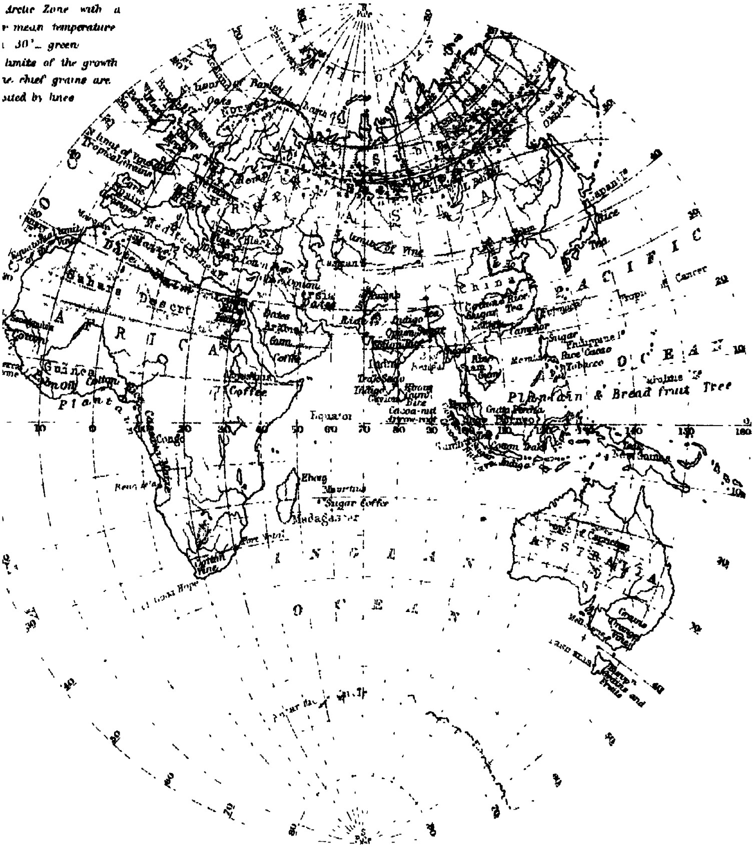
The Climate Zone of Tropical Flora with a greater mean temperature than 70° F is coloured pink, the Zone of Temperate Flora between 70° and 30° yellow and



W & A K Johnston

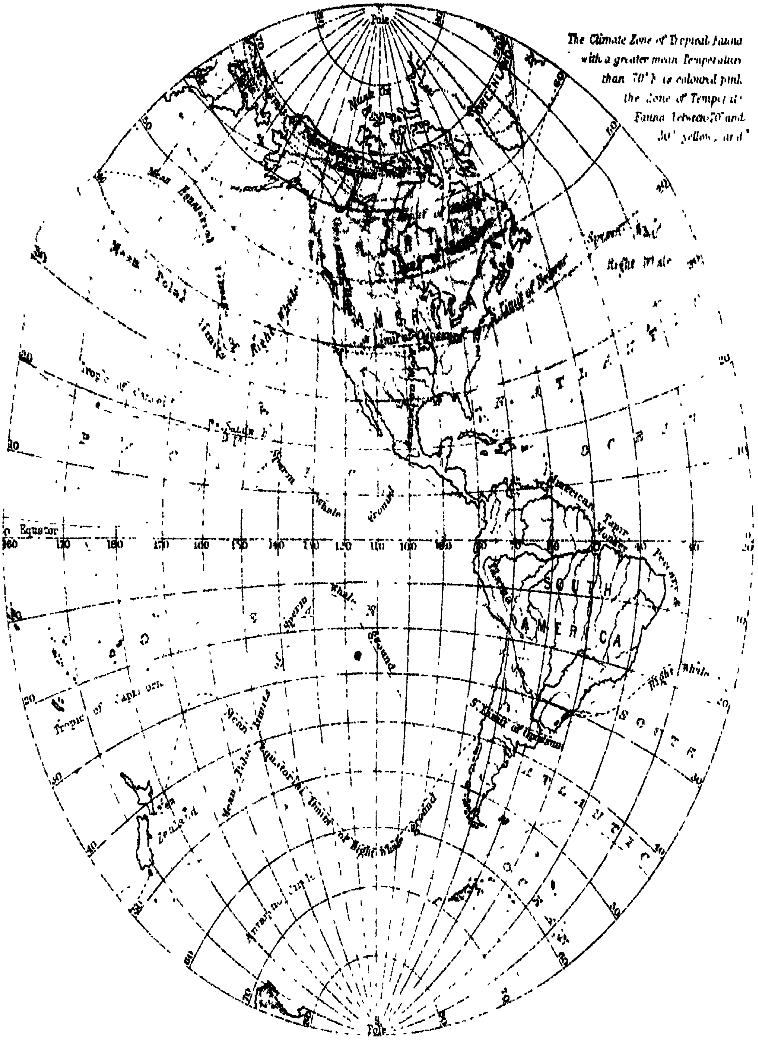
ISTRIBUTION
SEFUL PLANTS AND GRAINS

Arctic Zone with a
mean temperature
30° green
limits of the growth
the chief grains are
ated by lines



nburgh & London

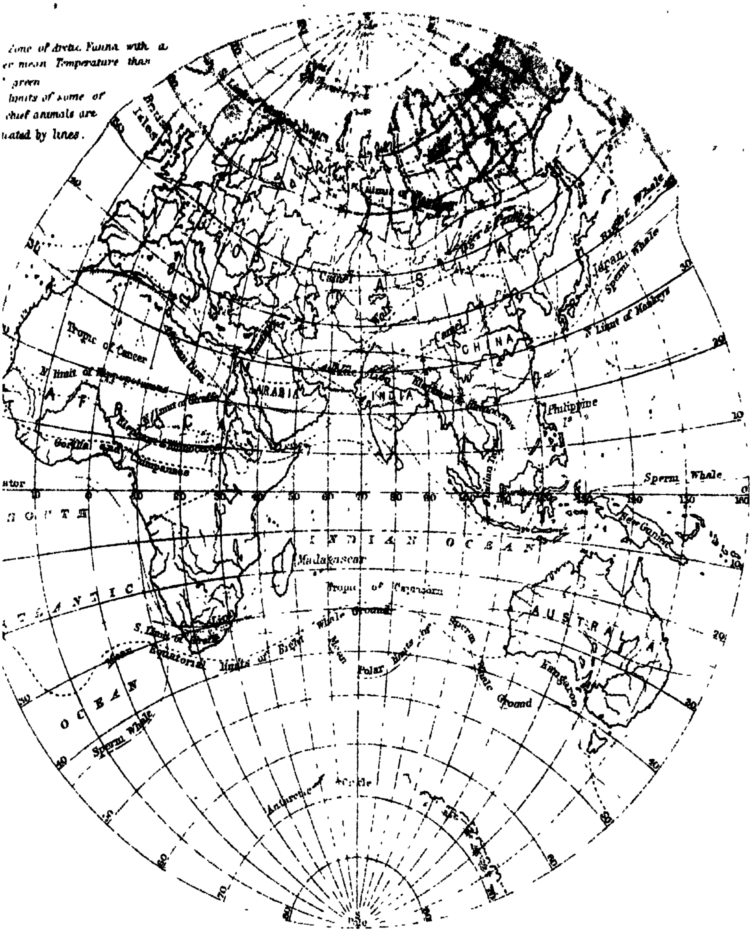
GEOGRAPHICAL DISTRIBUTION OF



The Climate Zone of Tropical Fauna with a greater mean Temperature than 70° F is coloured pink, the Zone of Temperate Fauna between 70° and 30° yellow, and

W & A K Johnston.

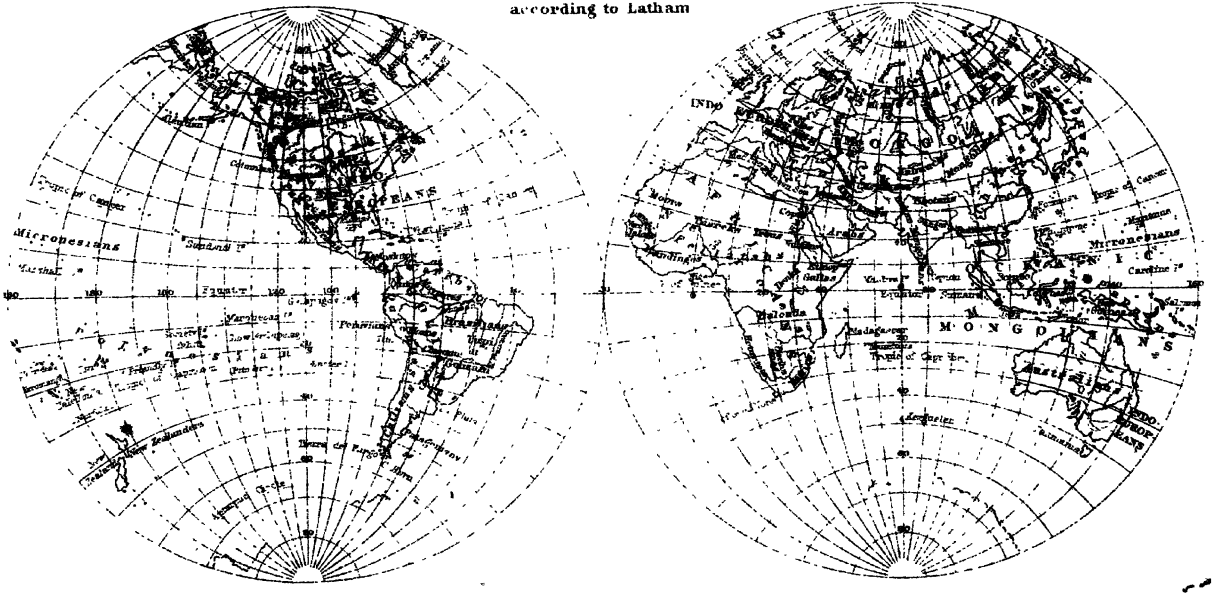
OME OF THE CHIEF ANIMALS



rgh and London

THE VARIETIES OF MAN

according to Latham



W & A.K. Johnston, Edinburgh and London

NOTE ON THE PREPARATION OF THE ATLAS.

THERE are several features in this Atlas which, since they are new, may, perhaps, be briefly noticed here.

In most Atlases of Physical Geography, it has been usual to employ only one projection for all the Maps of the Globe, and the projection generally adopted has been that of Mercator. Now, Mercator's development, as is well known, was specially designed for the construction of sailing charts, and for these it possesses unrivalled advantages; but when the cylindrical system is applied to a representation of the whole globe, it utterly distorts the true forms of the land and sea. It is easily conceived that this must be the case, since, in Mercator's chart, the smallest polar circles of latitude are represented by lines equal to the equator in length. One of the main endeavours in the preparation of this Atlas has been to avoid this uniformity, and by adopting varied projections, only one of which is cylindrical, to show the different parts of the earth from different points of view, so as to give the student as clear an idea of the relative size and form of these as is possible, when representing a globular surface on a flat one.

Then, further, that particular projection and position of the earth, which it was considered would best illustrate the subject of the Map, has been chosen for each; for example, in Maps 15 and 16, the world has been shown in hemispheres, one of which contains the whole system of the currents of the Atlantic and Arctic Seas, and the rivers flowing to these, at one connected view, whilst the opposite hemisphere embraces the entire Pacific system of currents and drainage. Maps 25 and 26 again, have been so arranged as to bring the centres or poles of volcanic disturbance into the centres of the opposite hemispheres.

The scale and projection of Maps of the quarters of the globe in most Atlases, is regulated by the size of paper on which the Map is drawn, so that the continents appear on very different scales, and no comparison, or, if any, an erroneous one, can be made between them; but in this Atlas the quarters of the globe have,—perhaps for the first

Map

AMERICA, SOUTH, the greater part in the land hemisphere . . 2
—— antipodal to Eastern Pacific . [illegible]
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W. AND A. K. JOHNSTON, EDINBURGH AND LONDON.

MIDDLE CLASS SERIES.

HAND BOOK

OF

PHYSICAL GEOGRAPHY.

BY

KEITH JOHNSTON, JUN.
F.R.G.S.

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NOTES ON THE MAPS IN KEITH JOHNSTON'S ATLAS OF PHYSICAL GEOGRAPHY.

INTRODUCTION.

ASTRONOMERS tell us that among the myriads of stars which are distributed in space, the sun, the centre of our system, is one. Round the sun eight planets revolve at unequal distances from it; of these, four nearer the sun are smaller, the four outer are of vast magnitude. One of the smaller of these planets, the third in distance from the sun, is the little earth on which we live, a sphere of less than a millionth part of the sun in bulk.

Movements of the Earth with and around the Sun.

The earth, in common with the other planets, is constantly moving in space, around and with the sun. Not only has it a motion of revolution round the sun in the space of time which we term a year, and a daily rotation on an imaginary line called its axis, but the whole solar system has been found to be rushing through space at a rate of one hundred and fifty millions of miles in a year.

The two minor of these motions visibly affect the condition of the earth; the constant slope of the axis of its rotation to the plane in which it moves round the centre of the system, brings different parts of its surface below the vertical rays of the sun, and produces the changes in the character of its surface and climate which we know as the seasons; and the daily turning of every part of the earth's surface towards, then under, and again away from the sun into its unilluminated side, gives morning, noon, evening, and night; but nothing is known of the universal and rapid flight of the solar system save the direction and rate at which it is now taking place; and whether it be a constantly direct motion, or a movement in a vast wheel round some greater and infinitely distant central body, or what its effect is upon the condition of our planet, is as yet unknown. Such are the movements of our earth as one of the heavenly bodies, the motions which are balanced between the attractive power of the sun, and the centrifugal force of the earth in its revolution, after an original impulse by a great first cause has been given.

The proper movement and life of the Earth.

Though thus controlled by superior force in its locomotion, our earth is in itself no lifeless and inert mass, but a wonderfully organized and moving being, endowed with a constant circulation in its every part, and with the power of changing its whole outward aspect. To study and mark this life of our earth, the nature of its present existence, and the changes which it has undergone, or which may take place in it, is the province of Physical Geography, one of the widest and most deeply interesting fields of human observation and discovery.

Far from its being thoroughly explored and known, the study of this proper life and circulation of our earth is as yet in its infancy, and there is no branch of Physical Geography which future observation will not greatly extend; as yet only the rude outlines of the earth's nature have been traced, the causes of many of the phenomena of its being are still vague and uncertain, and the knowledge of their mutual effects, and of the harmonies of their working, are still wanting to complete the view of the system of the world. But in what we do know of the proper movements of the earth's life we can see a wonderful process of circulation and change, of decay and renovation, never ceasing in its working throughout every part.

The main apparent causes of the Earth's proper circulation.

Two main causes are at work to produce this circulation, and these act either separately or in concert. One is exterior, the power of the heat and light derived from the sun; the other is interior, the subterranean heat and expansive force within the earth. The circulations caused more especially by the exterior power of the sun, are those of the atmosphere and of the sea, the upper and under flowings of those oceans of air and water which encompass the globe; and the beautiful circle, which connects these two, in the vapours drawn up from the sea into the atmosphere, which are distilled in rain upon the land, and return, after aiding life and growth, in streams to the ocean again. The other great process of circulation is caused by the expanding power of subterranean heat, and manifests itself in the gradual change of the face of the earth, in its submerging one, whilst upheaving another portion of the outer crust; this process, geologists tell us, has been in working for the long ages of the earth's history, each new formed continent bearing fresh and higher forms of animal and vegetable life, till at length the world was fitted for the habitation of man. This changing movement has not ceased, though it proceeds perhaps more slowly at the present time; so that the land which now forms our continents may, in course of ages, again become a part of the same sea-bed in which the strata now exposed on its surface were deposited, from the abrasion of the then existing land; for, even in our own days, the gradual rising of many parts of the coasts of the land, and the slow sinking of others, may be observed.

Constant change, then, whether of place, or form, or nature, characterizes every part of the earth, from the 'solid land' to the ocean or the air, as well as every living thing on its surface. Even mankind are not exempt from this; for we see older savage tribes inhabiting whole continents of the land, giving way and dying out before the newly-formed but civilized and progressive races which are gradually occupying their room.

In this elementary Atlas the more subtle powers of electricity and terrestrial magnetism—the nerves of the globe, which have also, perhaps, a considerable share in its economy, have not been noticed, and several equally interesting subjects have been necessarily omitted; but it is hoped that the rough outlines of the subject which have been given will suffice to awaken an interest in this subject, which constantly affects every inhabitant of the world, and to show that our earth, far from being a lifeless mass, is the beautiful work of an Almighty Creator, a wonderfully organized creature, moved and directed by vast powers within and outside of itself, which, under divine control and guidance, work harmoniously together for the good of man, but which, left for a moment unrestrained, might rend the earth and destroy its every inhabitant.

EXPLANATORY DIAGRAMS.

GEOGRAPHICAL TERMS AND CONTOUR LINES.

MAP 1.

A CORRECT understanding of the terms which have been chosen by geographers to designate those parts of the land or water of the globe which have a resemblance to one another either in extent or form, is necessary to their proper use in a description of the features of our earth, so that the definition of a few of the more important of these terms finds its proper place here. These terms, then, apply to the different shapes in plan and elevation which appear on the land of the globe, to the rivers which flow over the land, and to the seas and their branches which encompass it. As we shall afterwards notice there is considerable latitude in the use of these names, from the varying forms of the land and water, and there is on that account all the greater necessity for a knowledge of their proper meaning.

Terms applied to extent and form of Land in Plan.

First, then, considering the extent of the land of the globe, we observe that there are two great connected land masses, one called the Eastern, or Old World, because it was first known; the other the Western, or New World (as shown in the hemispheres of Maps 3 and 4), and many isolated parts of the land scattered between and about them. In these two great land divisions Political Geography recognizes five *continents:* those of EUROPE, ASIA, and AFRICA, in the Eastern, and of NORTH and SOUTH AMERICA in the Western World; whilst AUSTRALIA, the largest isolated piece of land, is considered as a sixth. Physical Geography, however, does not recognize the imaginary boundaries between these political divisions, so that in this view the land of the globe forms properly two *continents* only, since this term surely means continued or connected land; but, from their great differences in formation and nature, and for convenience of description, the parts of these two land masses, which are so slenderly connected by isthmuses (one of which is now actually cut through by a canal), may be considered as four separate continents, of Europe and Asia, Africa, North America, South America, and Australia, as a fifth. The forms of these continents, as we shall notice more particularly afterwards in the Atlas, are very *dissimilar*, some being broken into by the sea, so as to present ragged outlines, whilst others, or other parts of the same continent, have smooth and rounded shapes. Thus some parts of the land project beyond the general outline, to a greater or less degree, and some portions have been completely severed from the mainland, so as to be surrounded by the sea.

These smaller detached portions are termed *islands;* those parts which are nearly separated from the land are *peninsulas;* the larger projections, which are broader at their base next the land and thus have a firmer hold of it, are termed *promontories;* and the smaller extensions, as well as the points of peninsulas or promontories, are called *capes*.

These terms have, however, great range in their application. for the term island may be correctly given to any insulated part of the land smaller than the continent of Australia, whether it be of several hundred thousand square miles in extent or less than an acre; and the name peninsula is applied to all extending portions of land smaller than a continent: the proper application of this last term should be only to those projections which become narrower at their junction with the continent; those which are wider at their base are promontories. The name *cape*, besides meaning the head of these promontories, is properly given to every minor projection or angle of the coast, though when the coast is high or precipitous, the term *head* or *headland* is most frequently used.

An *isthmus* is the narrow part of the land which connects two large land masses, or unites a peninsula to the mainland. Here again there is considerable range in the term, since every part of a continent which may be called a peninsula must be separated by an isthmus; and this may be almost broken through by the sea, or remain of many miles in width.

Terms applied to the Relief of the Land.

Next we come to the terms used to indicate the form and relief of the land. *Lowlands* are level or undulating plains, which do not rise to any considerable elevation above the sea, and thus this term is nearly defined; but the name *Highlands* admits of several significations. It does not properly apply to *hills*, the minor heights of the land, which are either isolated, or in chains of variable length, this name being generally limited in its use to all heights below 1000 feet in elevation; but it includes all *mountains*, the heights of the land which are greater than hills, and all elevated masses of land, which are called *plateaux*, or *table-lands*. Mountains, like hills, may be either isolated peaks, or clusters, or ranges, which may extend for the whole length of a continent. Table-lands are elevated areas of the land, with either a mountainous or a level surface, or any gradation between these, unlimited as to height or extent, though the term is more usually applied to elevated land which is higher than hills, and wider than their tops. The term *plain* is given correctly to any extended level surface of the earth, whether forming a part of a lowland, or the top of a plateau, without regard to its elevation, though these levels are most extensive and frequent in the lower land. A *valley* is a depression in the general surface of the land, either between hills or mountains, or in the side of a plateau, scooped out by the action of the waters of a river, which is almost invariably found to traverse its length, though a groove in the side of the highland must previously have existed to determine the flow of the waters. A main valley, that is, the valley of a river which reaches the sea, has generally a number of minor valleys opening into it, marked out by the tributary streams of its main river; the height of its sides is only limited to the general height of the plateau in which it is cut, or of the mountains which bound it, and its depth, to the level of the sea, beyond which the waters of its rivers have no power. In mountainous countries the main valleys are generally continued in the *estuaries* of the river to the general line of the coast.

Terms applied to Water on the Land.

The consideration of valleys leads to that of the *streams*, which occupy and deepen them. The rivers of the globe have been grouped into *systems*, according to the seas to which they flow. The valley of a main river which reaches the sea is termed its *basin;* the valleys of its tributaries, the smaller streams which flow into it, are sub-basins. Its *source* is the beginning of the tributary which is furthest from the mouth of the river, in the direction of its windings, and the line which joins the sources of its tributaries, or the points where the waters deposited as rain begin to flow to one basin or another, is termed the *water-parting*, and the general slope of the land drained by the tributary streams, is called the *water-shed*.

The water-shed is termed right or left as it lies to these sides in looking down the course of the river; and the same distinction is made between the *banks* of the river. A river's *mouth* is perhaps best defined as the line at which its waters mingle with those of the *sea*; but since this point of union may be doubtful, or may vary, especially in tidal rivers, an arbitrary line has in some cases been drawn by jurisdiction, terminating some of the rivers. The *delta* of a river, a term originally applied to that of the Nile, is the land at its mouth, which is enclosed by branches of the river parting near the coast, and reaching the sea by different channels. Deltas are formed in flat coast lands, where the river has a weak current, by the mud which is brought down by the river being deposited in the middle of its mouth, and accumulating there so as to divide the stream into two or more channels. *Lakes* are generally formed in the hollow of a river course, or in a blocked up part of a valley. The water of the river fills up this hollow to the level of the lowest part of its barrier, and then overflowing, continues its course to the sea. Some lakes in the more desert and rainless parts of the continents have no outlet, and these are generally salt. The term lake applies equally to such vast spaces of fresh water as the lakes of Africa or America, as to the smallest sheet of water.

Terms applied to the Waters of the Globe.

The waters of the globe form one continuous unity, excepting a few disconnected inland seas and lakes. But for the convenience of location and description, this space of water has been divided into *oceans*, whose boundaries are partly formed by the solid land, and are partly imaginary lines, which follow meridians and polar circles.

The minor divisions of the oceans, generally marked out by some features of the land, or partly inclosed by a chain of islands, are termed *seas*; and special parts of the unenclosed ocean have this name, along with that of the land which is next to them.

Those seas which are nearly surrounded by the land, are termed *mediterranean*, that one which bears this name specially being the largest of them.

The term *gulf* is also applied to some of these mediterranean seas, such as the Persian Gulf and the Gulf of Mexico, which are larger than some of the seas properly so called. A gulf is correctly an inlet of the sea, which penetrates deeper into the land than the breadth across its entrance; and the term *bay* is applied to those inlets which are broader between their outer capes than their depth; but the two last terms are frequently interchanged. A *strait* is the narrow part of the sea which separates two continents or islands, or an island from the mainland, or forms the opening into a mediterranean sea; wider straits, or openings into them, are sometimes termed *channels*. *Inland* seas are those which have no connection with the ocean. Only three such seas exist on the globe, the Caspian being the largest; and it is remarkable that this, and another of them—the Dead Sea—are below the level of the ocean.

The features of Land and Sea mutually formed.

These features of the land and sea which are thus mutually formed, are each the converse of the other. The islands of the land correspond to the inland seas, the peninsulas to the mediterranean seas and gulfs, the promontories of the land to the bays, and the straits joining the mediterranean seas to the ocean, to the isthmuses which connect the peninsulas with the mainland.

Contour Lines.

The system of contour lines, or lines passing round the sides of the mountains or plateaux at an equal height throughout their course, which has been adopted in the Atlas, shows the actual elevation of the land; and the same lines applied to the depths of the sea, the coast being taken as a standard basis line between, give the form of the earth's crust beneath the waters. From these contoured Maps, sections may be drawn on any desired line, such as are shown in the middle of this diagram, from which an accurate comparison may be made of the relative heights of the land and depths of the sea, in and next any two countries, or in parts of the same land. The *horizontal* scale of these may be either the same or enlarged from that of the Maps, provided that the crossing points of the contour lines be marked at their proportionate distances from one another. The *vertical* scale, however, must be increased from the true natural height, which would be measured from the horizontal scale, in order to show the undulation of the land (in the sections drawn the vertical scale has been exaggerated to fifty times the horizontal one); but still, though such a scale increases the apparent slope and height of the mountains to an absurdity, these sections serve to give an accurate comparison of the relief of two countries. The section which is drawn brings out the great height of the land in Palestine, as

Sections drawn from the Contours.

compared with that of England, and the depth of the Mediterranean close to its shores, in opposition to the shallow seas round Britain.

Views of the Land from the Contours.

Again, sectional views of any part of the land may be drawn from these contours, in the manner shown at the foot of this Map, by drawing parallel lines from the salient points of the contours to a prepared scale representing their heights, and these views give an approximation to the appearance which the land would present to an observer at a point in the direction of the parallel lines.

Topography.

LAND AND WATER.

MAP 2.

THE Earth has long been proved to have a globular form, by its having been circumnavigated, by the constantly circular shadow which it throws on the moon during an eclipse, and by the phenomena of horizontal disappearance. Actual measurements of parts of the earth's surface show, however, that its form is not that of a perfect sphere, nor indeed of any mathematical body. To obtain the real length of the circumference of the earth, it was believed that by actually measuring by rule one degree of its surface, the length of it being marked out by the nadir points, or points vertically under two stars, a degree apart in the celestial sphere, and multiplying the degree thus measured by 360, the length of the circumference would be obtained; but most minute measurements of this kind, on various parts of the globe, show that the length of a degree varies in different parts of its surface, being longer towards the north pole and shorter towards the equator, thus pointing to a flattening of the globe at its poles, or a bulging out at the equatorial regions, giving the earth a spheroidal shape. The amount of this flattening, however, is different on the opposite sides of the globe, and the ratio of the difference between the polar and equatorial diameters of the earth, is found to vary between one 331st, and one 289th, part of the diameter, in favour of the equatorial axis. The form of the earth is, then, an irregular approach to a spheroid.

Form of the Earth.

The outer crust of this spheroid is also uneven, being hollowed out in the part of it which is covered by the *sea*, and raised in the parts which we call *land*,—the visible parts of the solid earth, which are above the level of the sea.

Nearly three-fourths of the earth's solid crust is thus hidden, being covered to a greater or less depth by water, so that the remaining fourth part only is exposed, and rises to a greater or less height above the level surface waters.

Area of the Earth's surface.

The whole area of the earth's surface, taking a mean of the major and minor axes,[1] is . .	196,712,850 sq. m.
The land on the globe measures	52,000,000 ,,
Leaving a surface covered with water of .	144,712,850 ,,

The proportion of land surface to water surface is thus as 1 to 2·782. Besides covering a far greater area of the earth's surface than the dry land, the hollow in which the sea lies, is supposed to sink generally much deeper below the level of its surface, which is taken as the zero point from which all heights or depths are measured, than the land is elevated above their level; or, in other words, that the cubic mass of sea beneath a given area is generally greater than the cubic measure of an equally large area of the land, taking the height of the land from the sea level.

Cubic mass of Land.

By taking the average of the elevation of the continents of Asia, South and North America, and Europe, as calculated by Humboldt (which is 925 feet, or 0·175 of a mile), as the general elevation of the whole land of the globe, we obtain the sum of 9,100,000 cubic miles as the total mass of land on the surface of the globe. This amount is perhaps rather under than above the reality, since the average height of the high continent of Africa has not been ascertained, though the increase in general elevation, which Africa would give, would be greatly counter-balanced by the lowness of Australia.

In his Physical Geography,[2] Herschel says, 'a *mean* depth of four miles may be taken for the sea, as one quite as likely to be beyond the truth as within it,' and he calculates the total contents of the sea at 788,000,000 of cubic miles. This, however, seems far in excess of the reality. The average depth of the Atlantic Ocean north of the equator, which occupies the only part of the sea-bed which has been at all well explored by the sounding-line, is less than two miles;[1] and this is apparently a deep part of the ocean, since the multitude of small islands appearing in the midst of the Pacific, would seem to argue that the greatest ocean is the shallowest of all.

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[1] As given in the Geodetical Tables of the Ordnance Trigonometrical Survey:—Major axis = 7926·6 miles; minor axis = 7899·6 miles; difference, 27 miles English.

[2] Physical Geography, from the 'Encyclopædia Britannica.' By Sir John F. W. Herschel, Bart., K.H.

Cubic mass of the Sea.

If the average depth of the sea be taken at two miles, which is perhaps still over the truth, its mass would then be 289,425,000 cubic miles, or 31·8 times that of the land; and *if* we conceive an equalising line which, passing round the globe, would leave a mass of the earth's crust above it, just sufficient to fill up the hollow which would be left below it, this line would then fall nearly a mile below the present level of the sea.

Unequal distribution of Land and Water.

The more elevated part of the earth's crust, the land, is not scattered over the surface of the globe in equal proportions to the sea, but, on the contrary, is confined nearly to one-half of the area of the surface of the globe, which half has, from this cause, been termed the Land Hemisphere; whilst the opposite one is distinguished as the Water Hemisphere. The Map shows the world divided into these hemispheres.

The pole, or centre of the hemisphere, which contains the greatest amount of land, is in latitude 51° 30′ N., and longitude 5° 30′ W. of Greenwich, at the mouth of the Bristol Channel, thus marking the British Isles as the centre of the habitable globe. The boundary of this hemisphere passes curiously along the angle of the Peruvian coast of South America, leaving only the tail of that continent in the Water Hemisphere: touches on the southern point of Africa, at Cape Colony, and, as strangely, skirts the coasts of China, including the whole of it in the land hemisphere. The most considerable mass of land left in the water hemisphere, besides the part of the South American continent, is that of Australia; and between these two is the unexplored and ice-bound region round the Antarctic pole, which may hide a continent as great as Australia, or may more probably be an archipelago of islands. It is obvious from this unequal distribution of the solid part of the earth's crust, that, if its average density be equal, one side of the globe must exceed the other considerably in weight, or the centre of gravity of the globe cannot coincide with its mathematical centre. If we take an outer shell of the earth of two miles, the supposed average depth of the sea, in thickness, and examine the present conditions of the distribution

One side of the Earth heavier than the other.

---

[1] For the detail of this calculation, see the description of the Map of the Atlantic basin.

of its weight, we find that the shell of the land hemisphere outweighs *that of the water hemisphere by an amount equal to eight* times the mass of the whole land of the globe.[1]

Longest direct extent of Land and Water.

The longest line which can be drawn in a great circle on the land without crossing water is that from Sierra Leone, in Western Africa, across the Isthmus of Suez, to near Shanghae, in Eastern China, a distance of one-third of the circumference of the globe: but on the meridian of 25° 30′ W. of Greenwich, the earth may almost be circumnavigated without meeting land.

Land generally antipodal to Water.

The shaded parts of the Land Hemisphere of this Map show the portions of the earth's surface which have land antipodal to them. Near the centre of the Water Hemisphere is Antipodes Island, the land most nearly opposite to Britain.

---

[1] The proportions of fluid and solid are distributed thus in these hemispheres:—

		Square miles.
Land Hemisphere, .	Land,	46,657,000
	Water,	51,699,425
Water Hemisphere, .	Land, .	5,343,000
	Water, .	93,013,425

		Cubic miles.
Then conceiving a stratum, or shell, of two miles below sea-level in thickness, the cubic mass of land in the land hemisphere with the earth's solid crust to this average depth of the sea below it	= 2·175 (46,657,000)	= 101,478,975
The cubic mass of sea in the land hemisphere, ...	= 2 (51,699,425)	= 103,398,850
The cubic mass of land in the water hemisphere, with the shell of the earth's crust below it .	= 2·175 (5,343,000)	= 11,621,025
And the mass of water in the water hemisphere, ...	= 2 (93,013,425)	= 186,026,850

Then taking the land as five times heavier than the water of the sea, and dividing the cubic masses of sea in the above hemispheres by this amount, to represent their weight as if it were land, we have the weight of the earth's fluid and solid surface for a uniform depth of two miles, equal in the land hemisphere to 122,158,745 cubic miles of land.

And in the water hemisphere to . 48,826,395 ,, ,,

Or a preponderance in the land hemisphere of the vast weight of . . 73,332,350 ,, ,,

Or the one half of the outer shell of far more than double the weight of the other.

The North Island of New Zealand is antipodal to Spain; the continent of Australia falls opposite the middle of the Atlantic, as if to counterbalance its great depression; the East Indies are antipodal to the plains of South America; and the southern part of that continent to the eastern part of Asia. Again, the continents of Africa and Asia seem to counterbalance the Central and Western, and South America the Eastern Pacific Ocean, whilst North America is entirely antipodal to the South Indian Ocean.

The area of land which has land antipodal to it is thus very small, and has been estimated at 2,653,000 square miles, or only a twentieth part of the land surface of the globe, so that the remaining nineteen parts of the land are antipodal to water.

This unequal distribution of sea and land has, as we shall afterwards have occasion to notice, a great influence over all the physical phenomena presented by our earth; on the climate and nature of the surface of the land, and consequently on the distribution of mankind, of plants and of animals, as well as upon the currents of the sea in moulding and limiting their course, and the direction and force of all the winds. The other planets of the solar system do not seem to share the present very partial distribution of land and water which characterizes the earth, if indeed the nature of their surface be the same, since viewed through powerful telescopes most of them present more regular bands, of different hues; the planet Mars, whose surface has been charted from repeated observations,[1] presents a great equatorial belt of supposed continents, and two narrower temperate belts with narrow seas between, a completely different and more equal distribution of land and water.

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[1] By R. A. Proctor, F.R.A.S., from observations chiefly by Dawes.

PERSPECTIVE VIEW OF THE GLOBE.

MAPS 3 and 4.

THESE hemispheres are drawn upon an orthographic projection, and are a representation of the earth as if from a point of view at an infinite distance from it, so that all lines reaching from this supposed point to its surface are parallel. This point is here conceived to be vertical to the Eastern and Western Hemispheres, and gives nearly that view of the earth which would be presented to an observer in the sun or in one of the planets, if his means of vision sufficed, comparable to the view of the planet Mars, which is obtained through powerful telescopes from our earth, and by means of which instrument, the apparently great seas and continents of that world have been mapped out. The central parts of the hemispheres thus drawn, are in nearly their true proportions; but the whole of the outer rim is greatly distorted, from the foreshortening of the view of the parts of the earth which here become more inclined towards the point of sight. This projection, however, gives the best outside view of the earth; the other projections of the sphere used in the Atlas, represent the hemispheres as if seen from a point in the centre of the opposite hemisphere.

The descriptions of the Maps which follow this, point out the more particular physical features of each of the continents, their plateaux or mountain ranges, their plains and depressions, and the special nature of their surface; but from this Map we can have a general and connected view of these great features of the earth, and of the nature of its surface as a whole. An approximate contour line of half-a-mile in height marks out the great highlands of the globe, distinguishing them broadly from the lower land; and in this view, the most of the land surface of the world may be considered as forming part of one great highland, or of one great lowland.

The great Highlands of the World.

The highland surrounds the Pacific and Indian Oceans. Round this great ocean we have, beginning in the Eastern Hemisphere, first the great South African plateau, continued in the highland of Abyssinia; then the plateaux of Arabia and of Persia; next the great table-land of Asia, stretching out on the north-east to meet the belt of highland in the Western Hemisphere; and lastly, the long table-lands and mountain ranges of North America, of Mexico, and of the Andes in South America. These great plateaux have generally a higher and a lower side, and it is observed, that the steeper side is in almost every case turned towards this ocean. The higher mountains of Africa lie to the east of the plateaux; the great range of the Himalaya faces the Indian Ocean; and the highlands of America slope steeply to the Pacific.

The great Lowlands of the World.

The great lowland extends round the Atlantic and Arctic Oceans. Beginning in the Eastern Hemisphere, North Africa forms a large part of the Atlantic lower land; next is the great plain of Europe; then the steppes round the great inland seas of Asia and the plains of Siberia. In the Western Hemisphere, the Atlantic basin is surrounded by the great lowlands which extend, in Eastern North America, from the Arctic Ocean to the Gulf of Mexico, and are continued in South America by the plains of the Orinoco, Amazon and Paraguay rivers, and in the pampas region to the south of these. The portion of this lowland which surrounds the arctic part of the Atlantic basin, is completely flat in the Tundra of Siberia, and broken into an archipelago of islands to the northward of America; but on the other sides a series of minor elevations and scattered ranges, separate the great plains from the coast. In the Eastern Hemisphere these minor heights are the Kong Mountains, and the smaller plateau of Barbary, on the western coasts of Africa; and the heights of Western and Southern Europe, the Alps, Pyrenees, and Scandinavian Mountains. In the Western Hemisphere, the hills in Labrador, and the Alleghany Mountains in the North, and the mountains of Brazil in South America, separate the central plain from the sea.

Minor Heights.

The broken chain of the islands, which form a partial barrier between the Indian and Pacific Oceans, lies nearly in the line of a great circle, joining the south-eastern peninsula of Asia with the termination of the South American continent, and so forms an exceptional part of the land surface of the globe. Their heights are almost invariably in the direction of this great circle; but Australia, excepting in the east, is a great lowland, in the midst of the high circle of plateaux.

In regard to the nature of its surface, the globe may be marked off in various irregular zones of different characters.

Icy Polar Regions.

Round each pole of the globe is a great icy region. In winter, when it is hidden from the sun, the greater part of the sea in this dark region is frozen over with ice; and in summer, when the ice is partly broken up by the warmth of the sun, it is floated down to more southerly latitudes, in great streams of 'pack;' or the glaciers of its higher islands break off, when they reach the sea, in huge icebergs, which are carried by the ocean currents far into the temperate regions. The Antarctic Icy Region is guarded by a great wall, or barrier of solid ice, which, in some places, rises from 150 to 300 feet in perpendicular height.

The 'Tundra,' or barren moss-covered land, which extends along the arctic shores of Asia, and of part of Europe, and the 'barren grounds,' the 'sterile' and 'swampy regions' of North America, as also the archipelago of rocky and moss covered islands to northward of it, and the great glacier field of Greenland, all belong to this northern icy region. The soil of the continental portion of this region in the north is constantly frozen to a great depth; and though its surface may be thawed by the long continued, though feeble warmth of the sun in summer, yet this heat does not penetrate the soil for more than a few inches. There is no continental part of the southern hemisphere corresponding to the Tundra region of the north, since the most southerly point of South America is not at a higher latitude than the island of Great Britain.

Temperate Forest Zones.

Bordering on the sterile zone of the barren grounds and the Tundra, is the temperate forest region. In the Eastern Hemisphere, this zone has the forests which extend in a broad belt almost continuously from the Scandinavian peninsula in Europe, to the east coasts of Asia, on the north of the Sea of Japan; and in the Western Hemisphere, the forests which stretch from the north-western peninsula of America, across the continent below the sterile regions, to the slopes of the Alleghany Mountains on the east coast. This forest region occupies the eastern part of the great plain of Europe, and nearly the whole of the great plain of Siberia, extending southward to near the Corea, on the east coast. Detached portions of it cover all the mountain slopes of Western Europe, and of the Caucasus, as well as the mountains of Asia Minor, and of Western Persia. In North America the forests extend down the western slope of the table land as far as California, but keep to the north of the western part of the Mississippi basin, and formerly covered the whole region to the east of this, but are now almost confined to the western slopes of the Alleghanies. Corresponding to this region in the Southern Hemisphere are the forests of the islands of Tasmania and New Zealand. the woods of the eastern slopes of the Australian coast range, and the forests of the Southern Andes, to the Strait of Magellan, in South America.

Two Zones of Pasture Land.

Next to this is the region of 'steppes,' 'pampas,' and 'prairies,' or 'savannahs,' wide plains covered with grass, of greater or less luxuriance. In Europe, the 'steppes' occupy a large area of South Russia, on the north of the Black Sea, and extend from that into Asia, round the north of the Caspian, bounded by the forest region on the north, characterising a wide extent of Western Siberia above the Sea of Aral and Lake Balkash, but narrowing to eastward where the pasture lands are confined to the northern slopes of the great table land. In North America, the 'prairies' and 'savannahs' in this zone, occupy the whole extent of the western drainage of the Mississippi River, from the forest on the north, to the slopes of the Rocky Mountains on the west, stretching south to near the swampy coasts of the Gulf of Mexico.

The Southern Hemisphere has a corresponding zone in the pasture lands in the west and in the east of South Africa, and in Cape Colony, in the 'downs' of the outer rim of Australia, and in the 'pampas' and rich pastures, which extend from the mountains of Brazil southward to the deserts of Patagonia in Eastern South America.

Desert Zones.

The next zone is that of the deserts, on the borders of the tropics. This region has its greatest extension in the deserts of the old world, which occupy more than a fourth part of its surface. These deserts of the Eastern Hemisphere are, for the most part, north of the equator, and extend in a wide but broken belt, from Western Africa to Eastern Asia. First and greatest of all, proceeding from west to east, is the Sahara of North Africa, covering a space greater than the whole of Europe, with arid, sandy, and stony plains and ridges. Next is the great desert of the plateau of Arabia, then the salt deserts of Persia, and those which extend northward round the Caspian and Aral Seas to the region of 'steppes,' the 'Thur' or Indian Desert, only separated from that of Persia by the river Indus, and, lastly, the deserts of the great plateau of Asia, terminating in the 'Gobi,' on the east. The parts of North America which lie in this zone, are the desert region of the great basin which surrounds the Salt Lake in the widest part of the table-land, and the deserts in the north of Mexico.

The desert zone is also well marked in the Southern Hemisphere. In the south of the great African plateau, is the 'Kalahari' desert, filling the central part of the continent there, and extending across the Tropic of Capricorn to the arid lands on the Orange River, and to the 'Karroo' desert of Cape Colony. The whole of Central Australia is in this desert zone, and it is continued in South America by the desert of 'El Gran Chaco,' in the 'Salinas,' or salt deserts, in the 'Despoblado' or 'Puna' region of the Central Andes, and in the arid coast-land at their base.

We have seen that this desert region is separated from the temperate forest zones in the Northern and Southern Hemispheres, by a belt of pasture land, and, approaching the equator, we again find that the deserts merge through a transition belt of pasture or cultivated land, to the luxuriant vegetation and denser forests of the equatorial region. This second pastoral and agricultural zone is most marked on the north of the tropical region, in the grassy, wooded, and partly cultivated lands to the south of the Sahara, in the productive lands of India, in the pastures of Eastern Tibet, and of Western China, and in the high cultivation of China proper. In the Southern Hemisphere this zone is marked by the fertile lands of central South Africa, by the 'Plains of Promise' in Northern Australia, and by the grass lands of Southern Brazil, and the La Plata basin, in South America.

Second Pasture Zone.

The last and central zone is that of rich luxuriant overgrowth of vegetable life, of dense humid forests and great swamps. In Africa, the representative part of this zone is supposed to occupy the whole of the centre of the continent, from the Lake Tchad region in the north, to the latitude of the Congo and Zambesi rivers in the south; and from the region of the great lakes, westward to the Atlantic coasts. This great area has been penetrated for a short distance on the north, west, and south, and has every where presented vast, and in some places, impenetrable forests. The Island of Madagascar is in the outskirts of the tropical forest region, and Southern India continues it into Asia, in the forests of the Ghauts and of Ceylon. The

Tropical Zone of Forests and Excessive Vegetable Life.

forests of the lower slope of the Himalaya belong to this tropical region, but those of the higher parts of the mountains, which rise into a colder climate, and are different in character, must be classed in the temperate forest region. Next are the forests of the southern part of the peninsula of Further India, of the islands in the Bay of Bengal, and of the East Indies. This zone seems also to touch upon the northern part of Australia, in the woods which surround the coasts of the Gulf of Carpentaria. The islands of the Central Pacific carry it across to its second great region, that which occupies the whole equatorial part of South America, Central America, and the West Indies. Here the varied forests occupy the whole vast area of the Amazon basin, extending southward from this on the eastern slopes of the Andes to the desert region of the Salinas: and in the north, cover the greater part of the continent to the Caribbean Sea and the Atlantic, the greatest exceptional area being the grass covered plains of the Orinoco River. This tropical forest extends also over the Isthmus of Panama and the greater part of Central America, reaching furthest north on the eastern slope of the table-land of Mexico, in the forests of the West Indies, and in the 'ever glades' of Florida.

These zones greatly depend on the rainfall and on the distribution of the vertical sun's heat.

The equatorial forest region lies chiefly in the central zone of almost constant rain; or in the belt on each side of this central one, in which there is a double rainy season, in spring and again in autumn, with a dry season between each. The Asiatic and East Indian part of the forest zone, is in the monsoon region, in which the rainy season of the land is determined by the direction of these periodical winds,[1] for when this wind blows on the land from the sea, it brings rain; but blowing off the land, the dry season. The greater part of the forest region here is, however, insular or between two seas, and so has rain from both monsoons.

The desert regions are again, either completely rainless, or have rain only in winter, being exposed during the whole summer to the unmodified heat of the sun. The temperate forest zones are, for the most part, in a second region in which rain may occur at any time of the year, though only for a short period at one time, and consequently in far less quantity than in the equatorial forest zone. It is in great part to this unequal distribution of the rains, produced by the currents of the atmosphere, that these varied zones of vegetation and desert are due; but the phenomena of rain, and of the character of the surface of the land, are also, to a great degree, dependent on one another, since we find that a once cultivated district, allowed to become desert through neglect, loses its former rainfall; or a desert country, if artificially irrigated and cultivated, obtains a rainfall where none previously existed.

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[1] See Map 22.

It is observed that the most of the deserts are in the zone which borders on the tropics, and their existence there may be accounted for, in great measure, also by the unequal distribution of the vertical heat of the sun. Some part of the tropical zone, of twenty-three and a half degrees in width on each side of the equator, is always receiving the vertical heat of the sun; but if we examine the motion of this zone below the sun, we find that the outer parts of it linger for a much longer time under the vertical rays than the central. If we divide the space within the tropics into ten equal belts, each of nearly five degrees in breadth, we find that the two outermost of these, in, and next which the deserts lie, are for more than seventy days during the year, continuously beneath the vertical rays, whilst the eight interior belts are only subjected to the direct rays of the sun for periods decreasing from sixteen days for the outer to twelve days for the central belts, twice in the year, at intervals of six months. Thus, a tract of country lying directly on the equator, receives in all, during a year, only a third part of that vertical heat of the sun, to which a district lying on either of the tropical circles, is subjected, and that heat is divided, not continuous, occurring in two seasons, with an interval of half the year between during which the sun's rays are indirect.

The Desert Zone is that of greatest temporary heat.

The frozen zones have their origin in the absence or feeble power of the sloping rays of the sun in these regions; but as we found that the hottest regions of the globe, those which receive most of the vertical rays of the sun, are not on the equator, but at some distance from it on each side, so here do we find, that by the unequal distribution of the sun's heat, the region of greatest cold is not at the pole, but in a circle at the same distance from it, as the regions of greatest heat are from the equator. When the north pole of the earth turns towards the sun during its yearly revolution round that body, it has its summer, and every part of the region above the arctic circle is, for a greater or less time, constantly bathed in sunlight; for as much as six months there is continual daylight at the pole, and

The Icy Zone is that of greatest cold.

the time of this perpetual light decreases outwards to the polar circle, beyond which there is a constant shadow side to the earth, and thus a break in the daylight, when the parts outside the circle of light daily revolve into the darkness. The heat derived by the regions round the pole from this long-continued, though feeble warmth of the unsetting sun, must be great, and such an amount of it is probably then stored up just round the pole, as to preserve a comparatively mild climate there during the year. But as we go southward from this pole towards the arctic circle, and across it, we are still in a region where the sun has at best a feeble heating power, and where, besides this, there is a daily, or rather nightly break in the continuance of its heat, counteracting and dispelling the warmth received by day; so that it is here in the belt surrounding the polar circles that the greatest cold is to be expected, not at the poles within these.

The extent of land covered by these zones.

The land surface of the globe has an area of 52,000,000 square miles. An estimate of the extent of this surface, which is still desert, including the sandy deserts of Africa, Asia, Australia, and America, as well as the barren grounds, the Tundra, and the icy lands of the arctic basin, gives upwards of 15,500,000 square miles, more than a fourth of the entire land surface of the world, of almost uninhabitable waste land. Again, the area of the earth's surface, which is more or less completely covered with forest, measures 12,500,000 square miles, and of this the tropical forest region occupies a greater share than the temperate.

More than one-half of the entire land of the globe is thus either characterised by forest or by desert, and the remaining area is in great part grass land, steppes, or prairies, a very small proportion only being cultivated.

EUROPE AND ASIA.

MAPS 5 and 6.

EUROPE and ASIA are considered as separate divisions of the political world, since they are distinct in the races which inhabit them, and in the advancement of these peoples in civilization; but regarded physically, Europe and Asia form one continent, the greatest on the globe.

In a general view of the form of this continent, we observe that its coasts are more broken into by the sea than those of any other of the land quarters of the globe; and that there are more numerous islands round them. Its outline forms a series of great gulfs, peninsulas, and promontories on all sides, with minor bays and projecting capes within these, contrasting strongly, in this respect, with the even-shored Africa, the other continent of the old world. Europe, extending to westward, with its many minor branches, may be considered as the greatest of these projections; on the south are those of Arabia, Hindostan, and Further India; the east coast has the mountainous southern peninsulas of the Corea and of Kamtchatka; whilst the low north coast is cut into by the long estuaries of the Arctic rivers, and stretches out in capes far to northward. The continent of Europe and Asia is also peculiar in the number of islands which surround its shores. Some of these are completely isolated, but most of them are but parts of the continent, a little more deeply cut into by the sea than the peninsulas which are united to the coasts. This is shown by the form of the islands continuing the direction of the elevation of the nearest land, or by the submarine connection shown by sounding. Thus, the British Isles are on a plateau which extends north-westward from the plain of France, clearly united to the mainland. The Islands of Corsica and Sardinia, in the Mediterranean, are but a southward continuation of the chain of the Alps; and Sicily, of the Apennines. The islands of the east coast of the continent, again, loop round a series of almost mediterranean seas; and by continuing the mountain chains of the peninsulas, show their intimate connection with the continent.

The two most separate islands belonging to the continent are those of Spitzbergen and Iceland; and these are also the furthest removed from its coasts, though the smaller groups of the Orkney and Shetland and the Faroe islands would seem to form a tie between the latter island and the mainland.

The southerly direction of all the high peninsulas of this continent has been often noticed with curiosity, and it may perhaps be due to an equatorial tendency of volcanic action.

The Highlands of Europe and Asia.

With regard to the distribution of the mass of this vast continent, in a general view, we observe that its higher regions extend in a great semi-circle round the west, south, and east, whilst the centre of the land is a great plain, extending to the northern coasts. The highland begins in the Spanish peninsula on the west, a table-land on which a series of mountain ranges, called 'Sierras,' from their jagged outline, extend from east to west, and rise highest in the Sierra Nevada on the south, and in the Pyrenees on the north.

Alps.

Next comes the high mass of the Alps, branching out southward through the islands of Corsica and Sardinia, through the peninsula of Italy and the island of Sicily, and continued on the east through Western Turkey and Greece.

Taurus.

Parallel to the extension of the Alps, but separated by the plain of Turkey, are the Carpathian Mountains, continued southward in a tortuous range, cut through by the River Danube, to the Balkan Mountains of Eastern Turkey. The main line of height seems to pass from Greece, through the high island of Candia, to the Taurus Mountains, the highest part of the plateau of Asia Minor. From this plateau depend the Mountains of Syria, extending southward to the group of Mount Sinai, and joining the western heights of the plateau of Arabia. Eastward from Asia Minor the main line of elevation follows along the heights between the head of the Euphrates valley and the Black Sea, to the western and higher edge of the plateau of Iran, or Persia.

Caucasus.

Parallel to this line is the higher, but more isolated, range of the Caucasus Mountains, and the range of the Elburz, which forms part of the northern side of the Persian highland. The continuous line of height curves round the south-eastern part of the plateau of Persia, to meet the great central knot of mountains of the continent, at the western corner of the great table-land of Asia. This is the point of union between the

Central mountain knot.

two great plateaus of Asia, and the isthmus between them is formed by the lofty range of the Hindoo Koosh Mountains, which stretch out westward on the north side of the plateau of Persia, towards the Elburz Mountains, and on the east, lead into the Bolor Tagh, the meeting point of the Asiatic ranges, and the highest plateau in the world, also called the Pamir Steppe, or '*Bam-i-duneah*,' the 'roof of the world.'

Great Table-land of Asia.

From this central point the Thian Shan and the Altai Mountains, branching out to the north-east, and the Himalaya range to the south-east, gives the direction of the edges of the great table-land of Asia, the highest land of the same extent on the globe. Through the midst of this *great highland a third high range, that of the Kuen-lun, seems to continue the central line of elevation to meet the Khinghan range*, the main buttress of the opposite side of the plateau. These mountains then carry the line of height northward to where it is broken through by the valley of the Amur River, but beyond this, the lower chains of the Yablonoi and Stanovoi Mountains continue it along the east coast far to the north.

The edges of the western part of the great table-land are sharply marked, for in them the land slopes steeply down to the plain; but on the eastern side, especially towards China and Siam, the table-land breaks into a multitude of mountain ranges, and so inclines more gently to the valleys and coast plains. This is particularly the case on the south-east of the plateau, where, from the narrow opening between the upper courses of the Brahmapootra and Yang-tsi Rivers, the mountains appear to pour out into the plains to the south, to form the numerous long ranges which stretch to south-west, south, and south-east, and bend round to eastward to form the main mountain range of Southern China.

The two most isolated highlands of the continent are the plateau of the Deccan, in Southern India, enclosed on the east and west by the Ghauts Mountains; and that of Scandinavia, in the peninsula to north of Europe. The maritime range, which extends on the east side of the continent, from the mouth of the Amur River to the Corea, is connected with the great plateau by the heights at the southern water-parting of the basin of the Amur River.

The chain of islands on the east side of Asia forms a part of the great volcanic girdle of the Pacific Ocean, curiously separated from the mainland by a number of nearly mediterranean seas, one side of

Eastern Chain of Islands and Seas.

all of which is formed by the coast of the continent, and the other by the island chain. Behring Sea, or the Sea of Kamtchatka, the most northerly of these, is surrounded on the east by the Peninsula of Aliaska and the chain of the Aleutian Islands, which stretch from it towards the middle of the Peninsula of Kamtchatka. The volcanic range is continued in the high mountains of the southern part of Kamtchatka, which peninsula, with its extension in the Kurile Islands to the north Island of Japan, encloses the Sea of Okhotsk; next, the high islands of Yesso and Niphon, form the eastern side of the Sea of Japan; the Yellow Sea is shut in between the Corea and the Loo Choo Islands, which continue the volcanic belt to the Island of Formosa; and this last island, with the mountains of Luzon and of Western Borneo, completes the Asiatic part of the girdle, and incloses the China Sea.

Direction of the Mountain Ranges.

In general the mountain ranges of Europe and Asia take a direction parallel to the great semicircle of the highest land which passes round the southern side of the continent. There is a remarkable parallelism and similarity in the south-western edges of the two great plateaux of Asia, where the range of the Himalaya slopes steeply down, in a direct line, into the plains of the Ganges and Indus, and where the lower but equally long eastern edge of the plateau of Persia falls suddenly to the valley of the Euphrates. The western slopes of the plateau of the Deccan, and that of Arabia, have also this direction, and this line of height seems to be continued in the mountains on each side of the Adriatic.

Heights.

The heights of the different parts of the elevated region of this continent are very varied. In the mountain ranges, the highest points are generally near the centre, and the higher side of the table-lands is invariably to the south or west.

Beginning at the west, the table-land of Spain has a general height of perhaps 2000 feet, since the line of half-a-mile in height on the map only marks out the higher regions. Its highest point is *Mulahacen*, 11,678 feet, in the Sierra Nevada, on the south; the second is in the Pyrenees on the north, the *Pic de Nethou*, in the Maladetta group, 11,168 feet above the sea. *Mont Blanc*, the summit of the Alps, is 15,780 feet in height; and *Monte Rosa*, near it, the second in elevation in this group, is 15,216 feet; but besides these there are more than twenty peaks in the range which rise above 10,000 feet in elevation. The *Gran Sasso*, the summit of the Apennines, in Italy, is 9544 feet in height; and *Mount Etna*, in Sicily, 10,834 feet. The highest point of the *Tatra*, in the east of the Carpathian chain, is 8685 feet; and of the Transylvanian Alps, the southern continuation of that range, is 8344 feet. The Balkan range, which continues the curve of the Transylvanian Alps, on the opposite side of the Danube, rises to 5900 feet, and the summit of the Rhodope Mountains, a shorter but more elevated parallel chain to the south, is 9842 feet. In the main line of the heights of Western Turkey, the highest point is not over 8000 feet; but in the mountain region of the north of Greece, *Mount Kiona* rises to 8783 feet; and in the Morea, several summits are above 8000 feet. *Mount Ida*, the summit of the Island of Crete, which is in the line of greatest general height, rises to 8500 feet; *Bei Dagh*, and *Bulghar Dagh*, the highest points of the Lycian and Cicilian Taurus Mountains, are respectively 10,500 and 11.407 feet above the sea; and the general height of the highland of Asia Minor, which is the western termination of the plateau of Persia, may be taken at half-a-mile (2500 to 3000 feet) though the average elevation of the ranges which inclose it on the north, and especially of that which bounds it on the south, is much greater. In the narrower part of the highland, between the plateau of Asia Minor and of Persia, *Mount Ararat* is 16,964 feet, and may be considered as the meeting point of the ranges enclosing the plateau of Persia. *Demavend* volcano, on the Elburz Mountains, which form part of the northern barrier of the Persian plateau, rises to 18,461 feet; but the southern ridge of this highland, though broader, and of a greater average elevation than the northern, does not seem to attain a greater height in any part than 11,000 feet. In the Caucasus range Mount Elburz, the summit, is 18,571 feet in height, and nearly the whole crest of the range to the eastward of this seems to rise above 10,000 feet.

There do not appear to be any very prominent summits on either side of the Persian plateau, till we arrive at the range of the Sulaiman Mountains, which shuts it in on the east, and slopes down into the plain of the Indus. Here the *Takht-i-Sulaiman*, or seat of Solomon, in the centre of the range, attains 11.301 feet in height. The peaks of the *Hindu-Koosh* Mountains, which extend westwards from the Pamir Steppe, on the north side of the Persian plateau, are as yet unmeasured, but probably rise above 20,000 feet. From the opposite side of the upper valley of the Indus River, the Himalaya chain extends south-eastward, forming the great buttress of the

Asiatic table-land, and the highest mass of elevated land on the globe, containing the highest of all mountains. In this vast range, upwards of one hundred of the measured peaks have been found to be more than 20,000 feet above the sea. The highest peak is that of *Mount Everest*, or Gaurisankar, 29,002 feet in elevation; but several reach nearly to this height.

The general elevation of the Kuen Lun and Thian Shan Mountains, seems to be not far short of that of the Himalaya. Several peaks of the former, near the western end of the range, where it branches off from the central knot, are above 21,000 feet in height. The absolute height of the summits of the mountains of China is unknown to Europeans, but as many of them surpass the snow line in this southerly latitude, their height must be accordingly great. In the Khinghan Mountains, on the east of the great plateau, *Mount Pecha* is estimated to be 15,000 feet in height. *Mount Belucha*, in the Altai Mountains, on the north side of the plateau, rises to nearly 11,000 feet, but the highland seems to decrease in general elevation to the north-west, and to expend its height in the long ridge of the Yablonoi and Stanovoi Mountains, which latter rise only to between 2000 and 3000 feet in height.

The peaks of the Eastern peninsula and island chain are very elevated. The summit of the Kamtchatkan peninsula is 15,825 feet. *Mount Fusi Yama*, an extinct volcano in the centre of the Japanese Islands, is 14,177 feet; and the culminating point of the Island of Formosa, *Mount Morrison*, is 10,800 feet. The Ghauts of India reach their greatest height in the Neilgherry Hills, almost at their southern extremity, rising there to 8760 feet. A central knot of mountains, in the Island of Ceylon, attains a considerable height, and *Mount Pedrotallagalla*, the summit of the island, is 8280 feet. The isolated chain, or plateau of Scandinavia, has its highest point in *Snehatten*, 7630 feet above the sea.

The mountains of the British Isles have the same general direction as those of the Scandinavian peninsula, though a deep part of the sea-bed lies between them. Their highest point, *Ben Nevis*, in Scotland, is 4406 feet in height.

The chain of the Ural Mountains, the political boundary between Europe and Asia, is the most opposite in direction of any of the mountain chains to the general line of elevation, since its course is due north and south. Its highest point, *Mount Konjakofski*, is only 5397 feet above the sea.

With the one break, caused by the comparatively low range of

Great Plain of Europe and Asia.

the Ural Mountains, the whole of the continent of Europe and Asia, east of the Scandinavian plateau, and to the eastern mountain chain of Siberia, is one vast plain, the greatest in extent in the world, occupying generally the northern drainage of the continent, but extending southwards in the central part of the continent, to include the northern drainage to the Black Sea, and a great basin of continental drainage to the Caspian and Aral Seas. That part of the plain which is drained to the northward, has naturally a gentle slope from the foot of the great plateau towards the Arctic shores, but the basin of interior drainage slopes gradually towards the Caspian Sea, which lies in a great depression, the lowest part of the continent, with the exception of the small but deeper area of the Jordan valley and the Dead Sea, in Syria. A large space, round the northern side of the Caspian, is below the sea level, and the surface of that inland sea is 84 feet below the level of the ocean.

The only great isolated plains of the continent are in the south, in the valley of the double river Euphrates and Tigris; in the north of India, the plain extending between the basins of the Indus and Ganges rivers; and the coast plain of China.

Nature of the Surface of Europe and Asia.

In respect of the nature of its surface this continent has, perhaps, the greatest variations of any of the land masses. Its great western peninsula, or the political division of Europe, is the part of the world which is farthest advanced in civilisation, and so presents the greatest area of cultivated land on the globe, but its surface is also very varied —in some parts still an uninhabited desert or unreclaimed forest.

Beginning at the south-east, we find that the plateau of Spain is more or less entirely a pastoral country, in some parts nearly desert, receiving very little rain, though its valleys and the coast plain next the Mediterranean, are more fertile and cultivated. The *Plain of France*, extending into the lowland of Belgium and Holland, is perhaps the greatest extent of cultivated land in Europe. Its hill ranges on the east afford excellent pasture, and are partly covered with forest. On the coast next the Bay of Biscay is a sandy and marshy district, known as the '*Landes*,' affording, in part, a scanty pasture, and in part covered with pine woods.

European Mountains.

In Southern Europe the slopes of all the more considerable mountain chains, as the Pyrenees, the Alps, and the Apennines, the Carpathian and Transylvanian Alps, the mountains of Turkey, and the high islands of Corsica and

Sardinia, are, for the most part, covered with woods or forests, and the lower land in the valleys, is generally well cultivated.

Low Countries.

The plain of Northern Europe is of a different character. The Netherlands, on the west of the great European plain, form a completely flat and low country, in some parts even below the level of the sea, reclaimed and protected from the inroads of the sea by great 'dikes,' and partly by naturally formed sand hills. It is drained by a network of great and smaller canals, and the land thus formed affords excellent pasture, or when cultivated, produces rich crops. In the east of the Netherlands, next the Prussian boundary, is a great extent of marshy heath; on the south-east a great morass is known as the '*Peel;*' and on the north of Belgium a similar, but more extensive tract of bog and moorland, is called '*Campine.*' The coast land of Hanover to the Elbe is, like that of Holland, generally below the sea level, protected by dikes; and between the river Weser and Elbe is the '*Lüneburg heath,*' a sandy tract covered with heath and scattered fir-trees.

Lake Belt of the European Plain.

One of the main features of the surface of Northern Europe is the great lake belt which surrounds the Baltic Sea. This belt extends from the lower Elbe round the whole water-shed of the Baltic, in Finland and Lapland, and in Scandinavia, eastward from the base of its plateau. The southern part of this tract, in Prussia, extends inland for more than 100 miles in general width, and is studded with innumerable small lakes and pools. The greater portion of the soil of this part of the plain is sandy and sterile, with heath and stunted pines; but parts of the coast land to the west and east of it, especially in the delta and valley of the Vistula River, are fertile and cultivated, though between these districts the shores are lined with barren sand hills. North-eastward this region is continued between the more fertile plain of Livonia, south of the Gulf of Finland, and the head waters of the Volga, and rises to upwards of 600 feet in general elevation in the heights of the Valdai Hills, which have numerous lakes. Lakes Ladoga, Onega, and Peipus, in this belt, are the greatest in Europe.[1]

Further on, the great 'rock and lake' plateau of Finland, at a general elevation of perhaps 250 feet above the sea, abounds in lakes, so that perhaps a third part of its surface is covered with water. The remaining third of dry land is rocky, or strewn with boulders, and the precipices of the plateau reach the coasts of the Gulfs of Finland and Bothnia.

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[1] For their extent and elevation see Map 21.

To the north, Lapland continues the lake region, and it seems to extend also into the Kola peninsula on the east. Eastern Lapland is an extensive sandy plain, in some places stretching out in deserts, and at others covered with low trees, but it has more fertile pasture lands round the lakes. In Scandinavia the lakes and swamps of this region occupy the valleys of the gentler slope from the plateau to the Gulf of Bothnia, and the parts between are covered with stunted pines and firs. To south of this the lake belt is in the more pastoral and wooded district of the Swedish mines, in the latitude of the broadest parts of the peninsula. A more fertile region surrounds Lake Wener; and between it and Lake Wetter is the central agricultural region of Sweden; but to south of this the termination of the peninsula is occupied by a more rocky lake region, with swamps and woods.

Scandinavian Plateau.

The declivities of the whole of the Scandinavian plateau are covered with vast forests of pine trees, but above the limit of their growth, the upper regions of the plateau have wide snow fields, or 'fjelds,' the largest in Europe, and immense glaciers depending from these into the numerous 'fiords' which intersect the high coast.

Plain of Hungary.

The plain of Hungary, surrounded by the forest mountains of Turkey on the south, of the Tirol on the west, and on the north and east by those of Bohemia and Moravia, the Carpathians and the Transylvanian Alps, is a great lowland, drained by the middle course of the Danube. The plain is generally of great fertility; but large tracts are barren wastes of sand, and next to the two great rivers which traverse its centre are extensive marshes, though these wastes are now being speedily reclaimed.

Eastern Europe begins the more thoroughly continental feature of this division; and in its more united bulk, we find the surface of the land divided into great zones of a more uniform character.

Tundra.

Beginning in the north, a belt of constantly frozen level ground, quite destitute of trees, and only covered with moss, extends from the eastern shores of the White Sea, near Archangel, along the whole north coast of the continent to the coasts of Behring Sea, with a general width of perhaps 150 miles, but attaining a breadth of at least 400 miles inland from Cape Severo, in the centre of the north coast of the continent.

This desert belt is called the '*Tundra*,' and corresponds to the barren and sterile regions of arctic America. From the edge of the Tundra southward, a vast forest region, one of the greatest on the globe, stretches from Scandinavia and the lake region of European Russia quite across the continent to the Pacific Ocean.

Forest Region.

This forest region occupies more than a fifth part of the whole area of the continent. Its southern boundary, or the point where it begins to merge into the less wooded pastoral country to the south of it, is approximately marked out by a line which, leaving the shores of the White Sea near Archangel, passes southward to the middle course of the Volga, turns gradually to northward from that to the line of the Ural Mountains, thence nearly along the parallel of 60° to the water-parting line between the Irtish and the upper course of the Obi River, along the northern slopes of the great plateau to the southern side of Lake Baikal, then round the broken north-east corner of the table-land to the crest of the Khinghan Mountains, and from that, in a diagonal line south-eastwards to the Corea. The great extent marked out by this line is one united forest, chiefly of pines, through which a traveller might pass for almost 4000 miles in a direct line. It is intersected by the great valleys of the Siberian rivers. The upper courses of the Yenesei and Lena rivers, though wooded, afford pasture, and are cultivated in parts; and in the district round Yakutsk on the Lena, from the valley of its tributary the Vilui River, on the left, to the Aldan, which reaches it on the right, innumerable herds of cattle find pasture. The valley of the Amur River breaks the continuity of the forest, and the parts southward of it have a different character. On the south side of this river there are many agricultural tracts and pasture grounds, both on the main river and in its tributary valleys.

Steppes.

Southward of the wooded region is that of the 'steppes,' or bare plains, which afford pasture for the herds of the nomadic tribes who inhabit them; in part almost desert, and in part covered with scanty herbage and grass. The southern boundary of this region is formed by the shores of the Black Sea, the northern base of the Caucasus, the limit of the depression of the Caspian Sea, and a line thence eastward to meet the wooded region at the corner of the table-land above Lake Balkash. There are numerous small swampy and disconnected lakes in the steppes, which have no outlet. In the north-east of the steppe, between the head-waters of the Irtish and Obi rivers, is a remarkably long and narrow depression, nearly 200 miles in length, and full of fir trees. The northern slopes of the table-land to the east of the steppe region, form a narrower but apparently much more fertile pastoral belt, merging from the forest on the north to the sandy wastes which occupy the table-land on the south.

The plateau of Asia Minor is an exceptional part of the continent from its position and elevation, and it has a great variety of surface: cultivated and populous valleys and outer slopes, wooded districts among the mountains, forests on the north coasts and in the eastern parts of the plateau; a large central area of interior drainage in the plateau is, however, a barren salt steppe, with several large and marshy salt lakes.

The isolated range of the Caucasus is also furrowed by very numerous valleys, all fertile, and highly cultivated; its mountain spurs are covered with forest; and the highest regions have snow fields and great glaciers. Southward from this, the western and higher parts of the table-land of Persia, and its slopes to the valley of the Euphrates and to the Arabian Sea, have varied fertile valleys and pastoral districts, covered with wood or even forest in some parts.

Deserts.

The next broad region of the continent is that of the deserts, a less continuous but also well-marked belt, stretching nearly across the continent, from the desert plateau of Arabia north-eastwards to beyond the Khinghan range at the extremity of the great table-land. The whole of the plateau of Arabia may be considered as a great sandy and almost waterless desert, broken only by a few fertile wadis, and of the same character as the sahara of Africa. The western and southern coasts of the peninsula, next the Red Sea and the Indian Ocean, are surrounded by a belt of arid sandy lowland, called the '*Tehama*,' of variable breadth, and supposed to have formed at one time a part of the sea-bed, from which it has been gradually raised. The slopes of the plateau, between this outer rim of sand and the deserts of the higher interior, are fertile and well cultivated. On the north, the plateau slopes gradually to the valley of the Euphrates, and from the depression of the Dead Sea eastward is called the Desert of Syria.

The plain of the valley of the Euphrates and Tigris possesses the *most fertile soil, once highly cultivated and supporting a large* population, but now it is encroached on by the desert, and great swamps have formed on each side of the lower courses of the rivers through neglect of the embankments which once directed their course. Now a great part of the country is used as pasture land, but many districts are now little better than a desert. A narrow and level strip of hot sandy desert, apparently corresponding to the 'Tehama' of Arabia, extends round the whole of the coast of the Persian plateau, widening in the east, where it has numerous salt marshes. The Persian part of this coast desert is termed '*Duhtistan*,' and that south of Beloochistan the desert of '*Makran*.' The more fertile southern slopes of the plateau separate this region from the higher desert which, with the exception of a few scattered and fertile oases, occupies the whole of the plateau in the interior.

The sands of the Persian desert are impregnated with salt; and a large swamp or salt lake called 'Seistan,' or 'Hamoon,' lies in the eastern part of the desert, and receives the waters of the river Helmund from the north-east, but its basin has no outlet.

North of the plateau of Persia, the lower *desert region of Turkestan* extends from the Caspian Sea eastwards to Lake Balkash. The depression on the north side of the Caspian belongs to this region. It is a great arid plain, with many marshes, saturated and encrusted with salt, so low that when the wind blows for any length of time from south-east, the waters of the sea flow over it for many miles. Between the Aral and the Caspian Seas an abrupt bluff plateau, called '*Ust Urt*,' rises to 600 feet above the latter sea. The rest of this region, from the south-eastern shores of the Caspian round the Sea of Aral to Lake Balkash, is a great sandy desert, only divided by the Amu and Sir Daria rivers, along whose courses there is a more fertile strip, especially in the lower course of the former river, where the inhabited part of Khiva has been rendered fertile only by most industrious irrigation; on the latter river there are great marshes. The part of this desert round the Sea of Aral has the appearance of an ancient lake-bed, and it is believed that this inland sea is becoming gradually dried up. The western slopes of the great table-land of Asia, and the high mountains which rise from it on this side, form a varied region of fertile valleys and bare mountain slopes, dividing the lower deserts from those of the plateau.

From behind the outer barrier of the Bolor and Himalaya Mountains, a continuous belt of desert, of variable breadth, stretches over the table-land of Asia to its north-east corner for more than 2000 miles, the greatest extent of waste in this continent, and only second to the great Sahara of Africa. The eastern part of it is called the '*Aksai Chin*,' or White Desert; the central part, covered with fine drifting sand, is the '*Hanhai*,' or the Sea of Sand; and the eastern portion, covered with sand and small stones, '*Ta Gobi*,' or great Gobi Desert. A part of its soil is impregnated with salt, and there are many brackish lakes in it. The general elevation of its surface seems to be about 3000 feet above the sea, higher on the outer limits and sloping down towards the interior. This great desert is cut into by a singular and completely isolated depression, a fertile valley extending from the base of the Thian Shan Mountains in the east, far into the desert region. This is the valley of the Tarim River, measuring, from west to east, nearly 1000 miles, very fertile and well-watered in its upper parts, where it produces all kinds of grain and fruits, and rich crops of cotton, but merging in the east into the desert, whose western edge here surrounds Lake Lob, into which the Tarim River flows.

A fertile valley in the desert region.

The eastern slope of the Khinghan range is covered with forest, but at its base a wide level desert plain called '*Kortchin*,' extends for more than 200 miles from the base of these mountains. Its character resembles that of the Gobi, generally covered with sand and having numerous salt lakes, but it has also frequent pastures. The '*Thur*,' or Indian desert, occupying the great plain to the east of the Indus, is also a lower extension of the great desert of the table-land, only separated from it by the forest covered range of the Himalaya. This desert extends southward to the salt morass called the '*Run of Cutch*,' and northward in the '*Doabs*,' between the five rivers of the Punjaub. The fertile valley and delta of the Indus, annually inundated by the melting snows of the mountains round its upper course, separate this desert from that of Persia.

Southern fertile region.

The part of the continent which lies south of the desert region in India and China, seems to have the general character of fertility, with wooded hills and mountain slopes, and cultivated valleys, or great extent of cultivable land, touching in its southern extremities on the zone of tropical vegetation and forest.

The plain of the Ganges is the most cultivated and populous part of India. It is separated from the forests of the Himalaya on the north by the '*Tarai*,' or swamp, which extends in a narrow belt along the whole base of the range from the Upper Ganges eastward. The western part of the Tarai is covered with long coarse grass, but the eastern is densely wooded with gigantic trees, and has a deadly climate. The whole of the great delta of the Ganges and

Brahmapootra rivers, the greatest in the world, is annually inundated over an area nearly equal to that of England, so that only the villages, which are protected by embankments, appear like islands during the inundation. This overflow begins in the end of May, and the land is again clear in October. The '*Sunderbunds*' is the continually swampy tract of the delta next the Bay of Bengal, overgrown with trees and thickets, the cradle of epidemic cholera.

The plateau of the Deccan, an elevated table-land with a level surface, excepting where it is cut into by the river valleys, has a generally rich fertile soil, well adapted for the growth of cotton; and the Western Ghauts, sloping to the Arabian Sea, have thick forests, consisting in great part of teak and bamboo.

The interior of China and Eastern Tibet, in this region, seem to be characterised by pastoral districts in the higher land, and fertile and cultivated valleys in the east. The numerous mountains in the south of China appear to have extensive forests. The great plain of China extends from the north of Pekin to beyond the mouth of the Yang-tsi-Kiang, with a variable breadth, stretching inland in the valleys. On the north, round Pekin, its soil is sandy and swamps are frequent on the coast, but the greater part of it is very fertile and highly cultivated, and is perhaps the most densely populated part of the earth's surface.

The islands of Japan properly belong to this region. Little is known to Europeans of the interior of these islands on account of the jealous exclusiveness of their inhabitants; but the parts of the middle island which have been seen, give evidence that agriculture is carried on there to its highest perfection, and every available spot is cultivated to supply the wants of a highly populated district. The steep declivities of the island of Formosa are covered with fine trees and pastures.

The peninsula of Further India consists of a series of long, but not very elevated, mountain ranges stretching southward, with corresponding wide valleys between. These mountains appear to be generally covered with forest. The valleys are well peopled, have great fertility, and are watered by numerous rivers.

Tropical Forest.

In the north-east of the peninsula, within the Gulf of Tongking, is a rich plain, a part of which is annually inundated. A hilly country, extending on both sides of the Lower Mekong River, and surrounding the great lake of Thale Sab, is entirely covered with tropical forest, but the delta of this river is low, and has marshy grass-covered plains inundated during the rains.

The island of Ceylon has a central area of mountains covered with vast forests, but round the outer part is a rich belt of lowland watered by numerous rivers.

The Andaman islands, in the Bay of Bengal, are also in the tropical forest region, and densely covered with trees.

Hydrography.

The great drainage system of the continent is that of the plain to the northward, and of the slopes of the higher land to the remaining sides, with an interior area of continental drainage, which comprises the whole of the desert region of Asia and the drainage of the River Volga, in Europe. The temperate climate of Europe allows free use of the deep gulfs which penetrate it from the Atlantic, and of its larger rivers, for the purposes of traffic and navigation, but nearly the whole of the Arctic coast of the continent is constantly ice-bound, so as to render nearly useless the great rivers of the plain, most of which would otherwise afford natural channels of communication far into the land, almost to the base of the plateau. The great rivers of the east coast, the Amur, Hoang, Yang-tsi, and Mekong, are navigable for a long distance into the interior; the Ganges and Indus rivers open up the plain of India; and the Euphrates river is a highway through the valley to the base of the plateau of Asia Minor. The greatest river of the continental drainage is the Volga, which supplies the Caspian Sea; and it is also the only one which, in the upper part of its course, drains a country which does not belong to the desert region. This is also the only navigable river of the Continental System.[1]

The Caspian, the largest inland sea in the world, has an area of 178,866 square miles, or considerably greater than that of the British Isles. Its navigation is dangerous, and is generally carried on in small vessels, but steamers cross it from north to south. Its waters are not so salt as those of the ocean, since a great supply of fresh water is constantly brought to it by the River Volga. The whole of the northern part of it is of a less depth than 60 feet, but in the south it sinks in the centre to a depth of nearly 3000 feet.

The Sea of Aral, only 26 feet above the ocean level, has an area of 27,000 square miles, or not far short of that of Scotland. Its waters are salt, and, like the Caspian, it has no outlet to the ocean. It is very shallow, the greatest depth being not more than 220 feet, but is navigated by fishermen, who use flat-bottomed boats. Lake Balkash is the third great inland lake of this desert region. Its surface is perhaps 700 feet above the sea, with an extent of 11,500 square miles. Its waters are also 'bitter salt,' and their greatest depth seems to be not more than 70 feet. Lake Baikal, on the northern slope of the plateau, in the upper basin of the Yenisei River, is the largest fresh-water lake, or sea, in this continent, having an area of 13,287 square miles, and is thus comparable in size to Lake Tanganyika, in Africa. Its surface is 1280 feet above the sea, and its greatest depth is perhaps 460 feet. It is regularly navigated by steamers from May to November, communicating with the plain of Siberia by the navigable Angara River, but in winter its surface is frozen over, and from January to April, traffic is carried on across its surface in sledges. The smaller lakes of this region, between the Caspian and Lake Baikal, are very numerous, both in the slopes of the plateau and in the higher and lower deserts. Lake Issyk-kul, one of the largest of these, has an area of more than ten times that of the Lake of Geneva, and is perhaps 5000 feet above the sea. The highest known lake of the world is also in this region, in the Bolor Tagh, at the source of the River Amu Daria, called Sir-i-kol. Its height has been estimated at 15,600 feet above the sea.

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[1] See Map 21.

NORTH AND SOUTH AMERICA.

MAPS 7 and 8.

THE physical features of North and South America are more sharply defined than those of the other great land masses. A great ridge of elevated land rises on the western sides of these continents, there is a lower and less united mountain region in the east, and between these a great plain or valley extends from north to south throughout their entire length.

Western Heights of NORTH AMERICA.

The western heights of North America continued through the table-land of Mexico to the Andes of South America, forms the greatest chain of mountains in the world, extending for a length of more than a third part of the circumference of the globe, and expanding near the centres of both continents into double ranges, with high table-lands between. Beginning at the north, we find that this chain is a continuation of the great volcanic girdle of the Pacific, which, leaving the Asiatic coast at Kamtchatka, is carried across to the American side of the ocean by the high volcanic peaks of the Aleutian Islands, forms the long peninsula of 'Aliaska, and then bending east round the coast culminates here in the volcanic peak of Mount St Elias, 14,970 feet, and continues thence in a due south-east direction, expanding in width, and again contracting, to the furthest corner of the wedge-shaped table-land of Mexico. From each of these two meeting points the range opens out into a double line of greater heights, enclosing a table-land between, which attain their greatest separation, and the plateau its greatest width in the centre of the continent. The eastern enclosing buttress of this

Table-land Enclosed by Outer Ranges.

table-land is formed by the Rocky Mountains, and the western by the coast range and the Sierra Nevada; both are continued southward as they approach one another again, in the mountains which rise from the sides of the table-land of Mexico. Several peaks of the Rocky Mountains rise to an average of 14,000 feet; the summit seems to be *Mount Hooker*, the height of which has been estimated at 16,750 feet. The coast ranges are not so continuous as those of the Rocky Mountains, though they seem to reach the same general elevation, being cut into three separate portions by the valleys of the Columbia and Fraser Rivers. The highest ascertained point of these is *Mount Shasta*, or 'Shasta Butte,' in the Sierra Nevada, which rises to 14,400 feet, but several points attain nearly to this height.

Great Basin.

Between these ranges the table-land has a general height of more than half-a-mile above the sea, though in some parts it rises to above a mile, but the valleys of the upper tributaries of the Columbia and Fraser Rivers cut deeply into it in the direction of the outer ranges. Between the head waters of the Colorado and Columbia Rivers the widest part of the table-land occurs, known as the '*Great Basin*,' which is at an average elevation of 5000 feet above the sea, and extends over more than 300,000 square miles, an area much greater than the whole empire of Austria. This great basin between the outer ranges, seems to be more or less completely a desert region of stony and sandy plains, interspersed with isolated hill ridges, bearing a few stunted trees, with mud flats impregnated with salt, and frequent dried-up lake beds. In the western part of the basin is the Great Salt Lake of America, 4210 feet above the sea, and several others which have no outlet to the sea. Further south, where the outer ranges begin to close, is the table-land of Mexico, in the northern part of which there is another high sandy and saline desert, apparently similar in character to the Great Basin. Where the ranges unite in the south of the table-land of Mexico, they form a plateau of much greater elevation, rising to an average height of 7 to 8000 feet. From this plateau rise the highest mountains of North America, the volcanoes of Orizaba, 17,734, and Popocatapetl, 17,729 feet, and several other peaks across the table-land above 12,000 feet in height. At the centre of this highest part of the plateau is a depression, in which is an oblong plain with four inland lakes; on the shore of the largest of these is the city of Mexico, 7468 feet above the sea. In the steep flanks of this highest plateau, as also farther to the north, are frequent deep, perpendicular fissures,

Table-land of Mexico.

called '*Barrancas*' or '*Cañons*,' in the bottom of which grows the most luxuriant vegetation.

Great Central Valley.

The central region of North America may be said to be one great plain or valley, from the Arctic Ocean to the Gulf of Mexico, rising gradually from the mouth of the Mackenzie River to 1500 feet at the sources of the Mississippi, and sloping thence gently to its mouth, having a lateral branch in the valley of the great lakes and of the St Lawrence, to the Atlantic.

Wooded Region.

From the Mackenzie River to the water-shed into Lake Superior, there is a thickly *wooded region*, a remnant of the original forest, extending along the line of the great chain of lakes from the Great Bear Lake to Lake Winnipeg; and also over the northern part of the western heights, from the arctic limit of trees, near the Yukon River, to beyond the 60th parallel southward, but afterwards only in the outer slope of the mountains to the Pacific, as far as California, leaving a great interior region which is almost destitute of trees. The *treeless region* extends over the whole of the central part of the western table-lands, and to near the Mississippi River eastwards. South of the forests in the central plain, at the edge of the woods, comes the '*Fertile Belt*,' 800 miles in length, watered by the North Saskatchewan River; a region which, by successive fires, has been cleared of the original forest growth, abounds in the most luxuriant herbage, and possesses a deep rich soil of vegetable mould. Beyond the water-parting, the wide treeless *prairies* and *savannahs* of the Mississippi-Missouri valley extend between the slopes of the Rocky Mountains on the west, and Lake Michigan on the east, southwards to the swampy flats of the gulf slope. The higher terrace of the prairie lands of the Mississippi valley, next the Rocky Mountains, has been called the *Great Western Plain*. A still higher part of the south of this plain, in Texas, is known as the *Llano Estacado*, from the stakes which guide across its wilderness. A vast tract of country at the lower part of the plain of the Mississippi is but little elevated above the sea, and is annually inundated by the spring floods of the river.

Mouths of the Mississippi.

To protect the cultivated ground from this inundation, banks of earth called *levées* have been erected on either side of the river, and extend for upwards of a hundred miles from its mouths upwards. From the constant filling up of the bed of the river by the mud which it carries down from the higher ground, and deposits in its less rapid lower course, this levée has constantly to be raised and carried farther up the river, but in spite of all care the breaks in it are frequent, and the inundations which follow submerge the land and destroy the crops, but repay the present damage by leaving a rich layer of mud on the land.

The *swamps* continue round the lowlands of the whole south-east coast, from the Mississippi to as far as Cape Hatteras, occasionally overgrown with pine and cypress, these parts being known as the '*Pine Barrens*.' The peninsula of Florida is low and flat, covered with wooded swamps, called '*Everglades*,' in the south.

Eastern Region.

To the east of this central valley are the '*Barren Grounds*,' between the shores of the Arctic Ocean and Hudson Bay, and to the east of that the '*Sterile Region*' of Labrador, so called from their having few fur-bearing animals, though the reindeer and musk ox are abundant. The Barren Grounds rise in many parts to 1000 and 1500 feet, and in the southern and central parts of Labrador the hills are 3000 feet above the sea. North of this are the rocky and bare islands of the Arctic archipelago, freed from their covering of snow only in the height of summer.

Greenland.

The surface of Greenland, as far as it has been explored, may be considered as one vast eternal glacier, resting on rocky mountains of considerable elevation, and moving with an almost imperceptible, but constant motion towards the sea on all sides, and reaching down into it at many points, there to break off in the huge icebergs which float unmelted far into the temperate zone. The western coasts of Greenland are intersected by numberless deep precipiced fiords, with only here and there a narrow strip of habitable land along the shore, on parts of which a little grass or stunted heath may grow in summer.

The southern shores of Hudson Bay and James Bay, inland to the water-parting of the rivers flowing to these, is a region of swampy tracts, separated by low ridges. This lowland, extending round the south of Hudson Bay, has been called the '*Great Northern Plain*.'

Beyond the valley of the St Lawrence, and between the great lakes on the north and the praries on the west, sloping up to the heights of the Alleghany Mountains, is a second region of '*Woodlands*,' the remains of the original forest of pine, maple, and oak, which formerly extended over the Atlantic slope also, but into which great inroads have been made in the advance of cultivation.

Alleghany Mountains.

The *Alleghany Mountains* form a series of parallel ridges, extending in a tortuous north-east and south-west direction, with a general height of from 1000 to 2000 feet, continued to the north in the White Mountains, between the St Lawrence River and the coast. The highest top of the Alleghanies is Black Mountain, 6707 feet, and of the White Mountains, Mount Washington, 6288 feet above the sea.

Great Lakes.

The chain of fresh water lakes extending from the valley of the St Lawrence to the shores of the Arctic Ocean, forms the greatest lake region of the world. The largest of these, Lake Superior, the highest in the drainage basin of the St Lawrence, covers an area considerably greater than the whole of Scotland or Ireland, and the whole chain taken together would form a sea not far short of the Black Sea in extent. The surface of Lake Superior is 627 feet above the sea, and at its greatest depth its bed is perhaps as much below the sea level. Lakes Michigan and Huron are at the lower level of 578 feet, Lake Erie at 565 feet, and Lake Ontario only 231 feet, the St Lawrence descending that amount between the lake and the sea. Thus the greatest descent is between the two last named lakes, 151 feet of which is in the great Niagara Fall. Lake Winnipeg, at nearly the same altitude as Lake Superior, drains to Hudson Bay by the Nelson and Severn Rivers: Lake Athabasca and the Great Slave and Great Bear Lakes, to the Arctic Ocean through the Mackenzie River.

WEST INDIA ISLANDS.

The West India Islands, the summits of a submarine elevation, form a chain uniting the continents in continuation of the lower heights of the eastern side, whilst the high mountains of Central America unite the great ranges on the west, and, carrying out this view, the Gulf of Mexico and the Caribbean Sea may be regarded as a depression in the great central valley of the two continents. This sea between the continents is supposed to have been at one time much more a mediterranean sea than it is at present, the channels between the islands on the east of it having been cut through and worn down by the constant action of the waves which now sweeps in a strong current through them, aided perhaps by volcanic agency. The chain of the West Indies rises to a considerable height in the western islands, the mountains in the south-east of Cuba rising to 7200 feet, the Blue Mountains of Jamaica to 7150 feet, and those of Haiti to 8900 feet from the sea.

The chain of smaller islands, '*Antilles*,' which extends in a curved line from these to the South American coast, is chiefly of volcanic origin. The central islands of Dominica and Guadeloupe have mountains of 5318 and 5113 feet in height, those extending on either side are lower, though some rise to above 3000 feet.

The *Bahama Islands* are the upper parts of the great coral reefs and banks which stretch for upwards of 800 miles north-east of the coasts of Florida, Cuba, and Haiti. The islands are generally long, flat, and narrow, covered with a light sandy soil.

CENTRAL AMERICA.

The physical boundaries of Central America are the Isthmus of Tehuantepec on the north, and that of Panama on the south. The region between these points is chiefly characterized by the great range of lofty volcanic mountains which extends along its western side, the highest being the volcano of Agua, 13,000 feet above the sea. On the north it opens out in the *table-land of Guatemala*, stretching into the peninsula of Yucatan, and has an average elevation of perhaps 5000 feet. South of this the more broken table-land of Honduras has an average height of 4000 feet, and beyond this plateau is the *plain of Nicaragua*, in terraced slopes of prairie and pine forests to the Mosquito coast. On the west of it is the Lake of Nicaragua, only 131 feet above the sea. From this to the lower Isthmus of Panama is a table-land, with a steeper slope to a narrow plain on the side of the Caribbean Sea, and a more gradual slope to the Pacific, rising to 2000 feet on an average, but to a much greater height in many of the volcanic peaks. Its two highest mountains are Chiriqui, 11,265 feet, and Pico Blanco, 11,740 feet. At the *Isthmus of Panama*, the two great oceans approach most nearly, at one point to within 30 miles of each other, and the summit level of the railway, which now crosses it, is only 262[1] feet above the seas. The immense commercial advantages which would be derived from a connection between the two great oceans at this point, in shortening the voyages from the centres of commerce in Europe to many parts of the world, have led to the projection of many schemes for the accomplishment of this object. The project of a canal to unite the Atlantic and Pacific Oceans dates from 1528, and has been called 'the mightiest event, probably, in favour of the peaceful intercourse of nations, which the physical circumstances of the globe present to the enterprise of man.' In a document of the United

Table-lands.

Isthmuses.

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[1] The lowest summit level in the isthmus of Darien is perhaps 100 feet below this.

States Senate of date 1866, on the subject of inter-oceanic communication, a list of twenty-six plans for this end is given. Nineteen of these projects are for canals, and seven for railroads, each taking advantage of one or other of the isthmuses between Tehuantepec and Panama, the Lake of Nicaragua forming a part of several of them, and some making use of the River Atrato, which nearly divides the isthmus from South America.[1]

SOUTH AMERICA.

Andes Mountains.

The Andes of South America form the longest unbroken range of lofty mountains on the globe. They extend from the Isthmus of Panama on the north to Cape Horn in the south, close to the western side of the continent, and so dispose its river systems that whilst some of the largest rivers of the world are found rising in, and pouring to the eastward of the Andes, no single river of importance flows westward from them. As in the highlands of the North American continent, so here the range is generally a double one, enclosing a high table-land. These higher ranges in the Andes system have the general names of the Eastern and Western *Cordillera*.

A western branch of the Western Cordillera extends to, and terminates at the Isthmus of Panama, but the Eastern Cordillera stretches in a curve to the north-east and along the coast towards the Island of Trinidad. The highest point in the Andes of the north is the Nevada de Tolima, 18,020 feet which rises from a central range between the outer Cordillera. To the south of this the different parts of the range are distinguished by the name of the country through which they pass. The *Andes of Quito*, or the *Equatorial Andes*, have two of the most important mountains of the whole chain—Mount Chimborazo, rising to 21,421 feet, on the Western Cordillera, the highest mountain of northern South America; and Cotopaxi on the Eastern, probably the highest active volcano of this range, or in the world, its crater being 18,875 feet above the sea. These peaks are not far to the southward of the city of Quito, which is situated in the valley or table-land between the ranges, at an elevation of 9534 feet.

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[1] A treaty for the construction of an interoceanic canal was signed by the United States of North America and of Columbia on the 14th February 1869. The canal is to unite the Gulf of San Miguel with Caledonia Bay, through the isthmus of Darien; the summit level here is stated to be about 164 feet (Doc. No. 62 of 39th Congress of U. S.). The treaty gives to the United States the exclusive power of construction, and grants 6 miles of land on each side of the canal. The measurements are to be completed in 2, the canal in 15 years.

In the *Andes of Peru* the Cordillera begin to open out, increasing in distance from one another to the southward. The Western Cordillera is a continuous line of summits, but the Eastern is here broken into by the valleys formed by the headwaters of the Ucayale, one of the main tributaries of the Amazon. The general height of the Andes, at this point, is not so great as to the north and southward. In the centre of the Western Cordillera of Peru, the highest point is in the Knot of Pasto, 11,800 feet, but near the Bolivian Andes some points rise as high as 17,000 feet.

Lake Titicaca.

In the eastern part of the Andes table-land, between Peru and Bolivia, a depression occurs. In the northern part of this high valley is *Lake Titicaca*, the largest lake of South America, and its surface is 12,847[1] feet above the sea. The extent of this lake may be compared with that of Lake Onega, in European Russia. The lake discharges a small part of its waters to the south into a second lake, lying in the same depression, and about 200 miles to the south-east of it, by the Desaguadero River, which gives its name to the valley. The second lake of the '*Pampa Aullagas*' has no outlet. This lake depression may be compared with the great basin of North America, since they occupy the same relative position in the highlands of both continents; but the valley of the Desaguadero is of far less extent than that of the Great Basin, being only about a tenth part of it, or equal to Ireland in extent, though it lies at more than double the height above the sea level.

The Desaguadero valley is above the limit of the growth of trees, and of almost all grains, but its plains are covered with the most luxuriant turf, especially near the lakes.

The average height of the Western Cordillera in the *Bolivian Andes* and of South Peru, is 14,000 feet, though several peaks, and among these the volcano of Atacama, rise probably to 20,000 feet. The Eastern Cordillera, or '*Cordillera real*' is of a generally less height than the western. The highest points of it rise just over Lake Titicaca, in the '*Cerro de Sorata*' 19,974 feet, and in '*Illimani*,' to the south of it, of nearly equal height. The central part of the plateau of Bolivia is characterised by a great salt plain, '*La pampa de Salinas*,' occupying an area of about 3000 square miles, and having

[1] Pentland; Reck, in Petermann's Mittheilungen, gives 12,605 feet.

a great lagoon in the western part of it, which becomes a salt lake in the wet season in winter, and again a salt desert in the dry summer. The southern part of the table-land is occupied by the salt deserts of Atacama, the '*Desiertos*,' a sterile region with many volcanoes.

Puna.

The 'Puna' region of the Andes is thus described by Von Tschudi.[1] Between the Cordillera (the Eastern) and the Andes (the Western Cordillera) at the height of 12,000 feet above the sea, there are vast tracts of uninhabited table-lands. These are called in the Quichua language, the '*Puna;*' the Spaniards give them the name of the '*Despoblado*' (the uninhabited), and they form the upper mountain regions of the South American Highlands. They spread over the whole extent of Peru from north-west to south-east, continuing through Bolivia and gradually running eastwards into the Argentine Republic. These table-lands present a curious contrast to the 'Llanos' (plains) of South America, situated on the other side of the Andes to the north and east. The aspect of the 'Puna' is monotonous and dreary: its expansive levels are scantily covered with grasses of a yellowish brown hue, and are never enlivened by fresh looking verdure. The cold climate and sterile soil are formidable impediments to agriculture, but the animal kingdom is richly represented in the llama and vicuña, the roe and chinchilla.

In the northern part of the plateau of the *Chilian Andes*, is the proper '*Despoblado*' between 22° and 28° S. latitude, a table-land of uneven surface, without any marked elevation at its edges enclosing it, between 12,000 and 13,000 feet above the sea: a desolate saline region above the limit of trees and cultivation. Neither of the Cordillera are prominently marked at this point; but on the south-east of the Despoblado, the peak of Aconquija rises to 17,000 feet.

Highest Point in America.

Beyond this, in latitude 30° S., there occurs a central range of greater height than the Cordillera on either side, which, presently turning to the eastward and descending into the plains, cuts off the Eastern Cordillera; and from this to the south-ward, along the whole chain, the Western Cordillera runs as a single range. Shortly after this, in the centre of the Chilian Andes, rises the highest known point in the American continents, the volcanic peak of *Aconcagua*, whose summit is 23,300 feet above the sea. South of this the tops of the range are from 11,000 to 12,000 feet in elevation; on the parallel of the volcano of Antuco the range is again double, enclosing a narrow longitudinal valley, and rises in some points to 16,000 feet. Afterwards the range rapidly decreases in height, the volcano of Osorno, in the south of Chili, being only 7550 feet in height. The mountains of Patagonia continue this descent, the highest summit in the north rising only to 7000 or 8000 feet, and Mount Stokes, farther south, to 6000 feet. The highest points in the continuation of the range, on the south side of the Tierra del Fuego, are Mounts Darwin and Sarmiento, 6900 feet.

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[1] Travels in Peru.

Central Plains.

The great central plain or valley of South America extends from the plains of the Orinoco in the north, to the deserts of Patagonia in the south. The '*Llanos*' of the Orinoco stretch between the river and the extension of the Eastern Cordillera of the Andes, and from its mouth to its tributary the Guaviare, over a space greater than the whole kingdom of Italy. These plains are characterised by swampy tracts near the mouth of the Orinoco, and on the coast, by great prairies destitute of trees and shrubs in the north and central parts, sandy table-lands in the higher parts near the mountains, and vast forests in the south, in continuation of the '*Selvas*' of the Amazon.

The plains of the basin of the Amazon are the greatest in the world. They extend from the mouths of that river across the whole continent to the base of the Andes, and in the wide country drained by its tributaries on either side, occupying an area greater than the whole of Central Europe, overgrown for the most part with impenetrable forests and underwood, bound together by luxuriant creepers. There are occasional '*Campos*' with fewer trees, or treeless plains covered with the richest grass. On the banks of the Amazon, as far as its junction with the Rio Negro, where it is only 130 feet above the sea, are swampy tracts, subject to annual inundation after the rainy season. The southern part of this plain towards the mountains of Brazil, consists of a vast alluvial region; and in the west of this higher ground, near the centre of the continent, is the sandy desert at the head waters of the Tepajos, called the '*Campos Parecis*.'

The country between the mountains of Brazil and the Andes, watered by the Madeira and its tributaries, is a continuation of the great central plain to the southward. The '*Pampa de Moxos*,' in this region, is a level tract with frequent lakes, supposed to be the partially dried up bed of a great lake. Further on between 18° and 20° S. the district of the water-parting between the tributaries of the Amazon and the Parana, is a level plain, swampy throughout the year, but almost covered with water in the rainy season. These swamps, covered with grass, canes, or rushes, are called '*Pantanaës*.' South of this the central plain between the Parana and the highlands on the west, is known as the '*El Gran Chaco*,' which has woods and pampas in the northern part of it, between the Vermejo and the Paraguay Rivers, but the southern half is a complete desert, with a dry saline soil producing no grass. To the south-west of the Gran Chaco, but separated from it by a narrow fertile tract, along the Salado River is another level salt desert, of the '*Salinas*,' covered for the most part with a thick salt efflorescence. The surface of this desert has been found to be only a few feet above the level of the sea.

The northern part of the country between the Parana and the Uruguay Rivers, is a vast impassable swamp, in some places more than 100 miles in extent, called the '*Ybera Lagoon*.' Further south these rivers are separated by a hilly district.

Beyond the Gran Chaco, and between the Salado and the Rio Negro, is the region of the '*Pampas*,' or grass covered prairies, with greater or less fertility, occasional swamps near the rivers, and saline tracts in the west.

The plains of Patagonia extend from the sea coast westwards towards the base of the Andes, rising gradually in terraces without vegetation excepting occasional tufts of brown grass and thistles, the soil consisting of shingle and whitish earth, with little fresh water, but frequent salt pools near the sea.

Eastern Heights.

The country between the plains of the Orinoco and the mouths of the Amazon in the north, is occupied chiefly by the ranges of the *Parime Mountains*, an almost unexplored forest region. The supposed highest point of these is Mount Maravaca in the south, estimated to be 10,500 feet in height. A continuation of these mountains probably forms the water-parting between the tributaries of the lower course of the Amazon, and the rivers flowing northward to the sea.

The mountains of Brazil in the east of the South American continent, form, with the Parime Mountains, the continuation of the lower eastern heights enclosing the central plains, and have the same relative position in this continent as the Alleghany Mountains have in North America. Very little is known of this hill region of the interior of Brazil. The highest ascertained points of these mountains are found in the '*Sierra do Esphinhaco*' next the coast, two mountains there having a height of 5750 feet. From this its main highlands stretch away to the north-westwards parallel to the direction of the Andes of Peru, with an average height of 2000 to 3000 feet, sending off branches to the north and south, the largest being that which extends round the valley of the San Francisco towards Cape St Roque.

On the south it extends as a table-land at the head waters of the Parana, a 'Pampa' covered with coarse grass and serving as pasture for great herds of cattle, horses and mules.

The higher coast range is continued to the south in the '*Sierra do Mar*,' the highest points of which are a little over 3000 feet. The extension of this range into the territory between the Uruguay river and the sea forms a smooth elevated plain, the richest pasture land in the world.

Navigable Rivers.

The limits of inland navigation are indicated on the maps, by showing the points to which vessels may ascend the rivers. No other countries in the world are so splendidly provided with natural highways as the Americas. In the north the great Mississippi opens up the land to commerce for 1600 miles of direct distance from the sea, nearly meeting the navigation by the St Lawrence and the lakes from the east, so that these two rivers, with their tributaries, provide ready means of communication throughout the whole of the more productive part of the country. In South America the mighty Amazon,—the greatest river of the world,—gives access to the whole of the great South American plain, from the Atlantic to the very base of the Andes, 2000 miles westward from its mouth, and far to the south and north by its tributaries, one of which, uniting in a wonderful manner with the Orinoco river in the north, completes a circuit of navigation to the ocean again on the north coast of the continent. The southern part of the continent too, is provided with a great natural highway in the Parana River, which leads for 1200 miles into the heart of the land, behind the highlands of Brazil.

AFRICA.

MAP 9.

THE vast mass of land called Africa is the typical continent of the globe. This designation is particularly applicable to it from the compact unity of its bulk, and the almost unbroken nature of its coast-line, when compared with the other continents. Its outline is very remarkable in this respect, that it is not cut into by any inlet of the sea. It has not even any considerable river estuary; and the few islands round it, with the exception of Madagascar, are small.

The southern half of the continent is a great elevated plateau, rising higher at its edge next the coast; but the northern half, with the exception of a smaller plateau on the north coast, is a much lower region, sinking, in some parts, even below the level of the sea.

In respect of the nature of its surface, Africa, the only one of the continents which has a large extent of land on each side of the equator, presents a series of changing zones, which correspond very closely with one another in the opposite hemispheres. Thus the central area of Africa, in the zone of frequent tropical rains, is a region of dense forests and most luxuriant vegetation. To north and to south of this equatorial zone is a belt of less wooded country, merging into cultivated and pasture lands. These grass-lands again, pass into the two great, almost rainless, deserts of Africa, the southern of which extends down to Cape Colony, whilst the northern, the greatest desert on the surface of the globe, stretches almost to the Mediterranean coast. Beyond the deserts, at the extremities of the continent, the southern coast-slopes of the high land of Cape Colony, present a more fertile country, and corresponding to this in the north, is the cultivated watershed of the plateau of Barbary next the Mediterranean.

The South African PLATEAU.

The great South African Plateau is, next to that of Asia, the most extensive highland of the globe, since it embraces the whole of the continent south of the tenth parallel of north latitude; and though it does not attain the same average height, it is much less broken into than that of Asia. The contour line of half a mile on the map, shows the rise of the table-land to this elevation at an average distance of from one to two hundred miles from the coast, and its general elevation throughout may be perhaps taken at 3500 feet.

Contrary to the case of North and South America, we find the greatest heights of Africa extending in a line of high table-lands and mountains along the eastern side of the continent. On the south the mountains of Cape Colony rise in a series of terraces and ridges from the coast inland to their highest range, which forms the water-parting of the rivers flowing southward to the ocean, and of the periodical streams which reach the Orange River to northward. Compass Berg, the highest point of this inmost range, is 8500 feet above the sea. These heights are continued round the south-eastern side of the African Plateau by the Drakenberg Mountains, rising in some points to above 10,000 feet in elevation, and afterwards turning backward towards the interior in a high plateau, which divides the head waters of the Limpopo from those of the Orange River. On the southern slopes of these mountains are the colonies of the Cape and of Natal. To northward of the Drakenberg, the higher edge of the plateau is broken down by the valley of the Limpopo River, but rises again further inland between this river and the Zambesi, in the Matoppo Mountains, the gold region of South Africa,[1] which attain, in one point, the height of 7200 feet. Beyond the Zambesi, the eastern heights are continued in the mountains which surround the great Lake Nyanja, on the edge of the plateau, between which and the smaller Lake Shirwa, Mount Zomba rises to 7000 feet, and a second mountain near it to perhaps 8000 feet.

Nearing the equator, the eastern range attains its greatest elevation in the snowy peaks of Kenia and Kilima Ndjaro, which are estimated to be 20,000 feet in height. These are probably the most elevated points in Africa. A high range seems to unite these mountains with the table-land of Abyssinia in the north, which is an extension of the South African Plateau, and the generally highest land of the continent.

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[1] Recently discovered by the traveller Mauch.

Plateau of Abyssinia.

The plateau of Abyssinia has a wedge shape, the point being to northward. Its eastern side is a uniform line of steep descent, unbroken by any river, to a low plain extending to the Red Sea; and its western side, though broken into by the numerous deep valleys of the rivers flowing to the Nile, forms a general line meeting the eastern edge from the south-west. The average height of the plateau may be taken at 7000 feet, though its general elevation is greatest on the eastern edge, which forms the water-parting of its rivers. These rivers, flooded by the violent rains from June to October, have cut the deep narrow valleys which characterize the Abyssinian highland—some of which are more than a thousand feet below the general level of the land. Its highest mountain, Abba Jared, one of a lofty group in the north of the table-land, is estimated at 15,000 feet in elevation. The heights of the Nubian desert, between the Nile and the Red Sea, terminate this extension of the southern plateau.

The northern edge of the African Plateau seems to pass across the continent, between the 5th and 10th parallels of N. latitude, from the north of the great lakes at the head of the Nile to the Camaroon Mountains on the west coast, having at its north westerly extremity Mount Atlantika, 10,000 feet in height, south of Lake Tchad. The Camaroon Mountains on the west coast, at the corner of the Gulf of Guinea, form a group nearly detached from the plateau, rising in the form of a high peninsula of mountains from the coast-land to 13,760 feet. With this one exception, the western edge of the African Plateau is not marked by any very prominent heights, such as characterize its eastern side, but its slope is generally closer to the coast, and in some places in the south approaches to within a few miles of the shore.

Character of the Surface of the African Plateau.

The coast land, and the outer slopes of the south part of the African Plateau, are generally well watered and fertile: the greater part of the interior is desert. In the Cape Colony, the Great Karroo Desert, an utterly bare and barren waste, extends, in an elevated plain, between the outer and the inner range of mountains, for more than 350 miles, and with an average breadth of 50 miles across. Beyond the inner range, the water-shed to the Orange River, is a more or less sterile country: its rivers, only filled after heavy rains, rise very suddenly, and become formidable torrents, which have cut deep ravines far below the general level of the land. The only permanent stream in this region is the main one of the Orange River.

Kalahari Desert.

From the Orange River the great desert of South Africa, the 'Kalahari,' extends northward for 600 miles to Lake Ngami, having a general width from east to west of at least 500 miles, and occupying an area greater than the peninsula of Spain. This desert is a vast sandy plain, at a general elevation of perhaps 3500 feet above the sea, covered with coarse grass and bushes, which wither and crumble to dust in the hand in the dry season; it is without rivers, and almost without water, which is only found in a few scattered wells or springs. The western coast land, at the base of the plateau, in the latitude of the Kalahari, is also a sandy desert; but the higher part of the table land between these seems to consist rather of open pastoral country. Smaller areas of sandy desert extend beyond the Kalahari to northwestward, towards the head waters of the Congo River, interspersed with regions of woodland and swamps.

The south-eastern part of the plateau, between the Kalahari and the valley of the Zambezi, and to the inner side of the eastern range, consists of pasture land, more or less wooded and cultivated. The northern water-shed of the Limpopo River is thickly wooded, and the valley of the Zambezi has a forest on each side, with cultivated land near its mouth.

Ancient Lake Beds.

Lake Ngami is small when compared with other great African lakes, being only about 30 miles in length. The land surrounding it is annually flooded, and it is remarkable that this rise takes place during the dry season from May to October. West of it are numerous 'salt pans' or lagoons, great depressions encrusted with salt,—one of which was found by Dr Livingstone to be more than 100 miles in length, and 15 miles in average width. A river extends over the flat country, between the lake and these salt lagoons, and loses itself among these. From these appearances it has been concluded that this region is the ancient bed of a great lake.

North of this, and between the main tributary river of the Ngami Lake from the north-west, and the Zambezi, the land is still a complete level, with numerous streams and vast slimy swamps; during the rainy season, the whole country is flooded, so that it then presents the appearance of a great lake with scattered islands. Beyond this to westward, sandy flats and swamps continue the inhospitable region of the Kalahari; but on the western side of the

Southern fertile Belt.

plateau, in this latitude, the surface of the country changes to a more elevated and undulating region, fertile and well cultivated in the southern part, becoming thickly wooded to northward. The land of the Balonda, occupying the whole upper part of the water-shed of the Zambezi, is described by Dr Livingstone as fertile and pleasant. In it, dense woods interchange with open grassy plains and meadow-like valleys. Angola, the country embraced by the Congo River on the north, is a fertile and beautiful province, in the highest degree adapted for cultivation and traffic.

The north-eastern part of the African Plateau is the great lake region, which has recently been entered by travellers; but the north-western part is still the greatest extent of unexplored land on the globe, equal to a third part of Europe in area. Where it has been penetrated on the east and west, it has been found to be a region of dense, and in many parts impenetrable tropical forest and most luxuriant vegetation, well peopled, and abounding in animal life of every sort.

Lake Region.

Lake Nyanja, the most southerly, and perhaps, the best explored of the great African lakes, lies on the eastern edge of the plateau, surrounded by high mountains. It is 250 miles in length, and of an average width of 50 miles. Its surface is 1500 feet above the sea, and the lake is of great depth, so that Dr Livingstone supposes that its bed, may be below the sea level. The River Shire, with numerous rapids, drains it to the Zambezi. South of it, the smaller Lake Shirwa, 2000 feet above the sea, also between high mountains, has no apparent outlet, and its waters are brackish.

The country between Lakes Nyanja and Tanganyika has been recently explored by Dr Livingstone, and his letter, of date 1868, describes this region as a table-land of from 3000 to 6000 feet above the sea, generally covered with dense or open forest, with an undulating or hilly surface, and rich soil watered by numerous rivulets. The country to the east of this affords pasturage to immense herds of cattle. The streams from this plateau flow westward into a great valley enclosed on the south by the high range of the Sierra Muchinga, and on the west by the Kone Mountains. The chief stream of this plateau is the Chambeze, not to be confounded with the Zambeze river. This river flows into an extensive marshy lake called Bangweolo, which lies in the head of the valley; from this it turns northward under the name of Luapula, and forms the lake named Moero, to the south-west of Tanganyika. Emerging from this lake through a rent in the mountains of Rua, the river, with the again changed name of Lauluba, flows north-westward to Ulenge, a marsh in the country west of Tanganyika. This river and lake chain is then either the head stream of the Nile, or of the Congo River which reaches the Atlantic, and the probabilities are that it belongs to the latter river. Four other considerable streams flow from the plateau north of Lake Nyanja westward into the smaller Lake Liemba discovered by Dr Livingstone. This lake lies in a hollow of the northern edge of the plateau, 2000 feet below its general level, and is a branch of Lake Tanganyika. joined to it by a broad river lake prolongation. If the Chambeze River be the head stream of the Congo, then these feeders of Lake Liemba must prove to be the long sought sources of the Nile; in either case, the honour of the discovery is due to Dr Livingstone.

Lake Tanganyika is of the same long and narrow shape as the Nyanja, and measures more than 300 miles from north to south. Its elevation is perhaps 2800 feet above the sea. and its drainage is to the valley of the Nile, since Dr Livingstone has shown that Tanganyika and the Albert Nyanza are 'one water.'

Victoria Lake, one of the main feeders of the Nile, 3500 feet above the sea, the southern and northern extremities of which were explored by Speke, if it be indeed a united lake of the dimensions supposed, is the largest and highest of the African lakes, covering an area of nearly 30,000 square miles, or the same as the whole of Scotland, and thus rivalling Lake Superior for the place of the greatest fresh water lake on the globe. The Albert Lake, recently discovered by Baker, is supposed to be not much inferior in extent to the Victoria Lake, and is also a chief reservoir of the Nile. Its height above the sea is less, being only about 2500[1] feet. Further west, a fourth great equatorial lake has been reported by ivory-traders, perhaps equal in area to the Victoria Lake, but not connected with the Nile basin. From it a river flows in a north-westerly direction, as if to join or form the origin of the broad and deep river which the traveller Barth found flowing to Lake Tchad from the south-east. Including the reported lake, the equatorial lakes of Africa would cover a space not less than the whole island of Great Britain in extent.

[1] Baker, 2720 feet. Corrected barometric height by Buchan, from Baker's observation, 2530 feet.

In reaching the Tanganyika and Victoria Lakes, the travellers from Zanzibar, after crossing the outer ridge of the African plateau, passed over a great salt desert, generally covered with thorn jungle, but afterwards the country between the lakes, presented grassy plains and populous cultivated tracts.

Central Forest Region.

The great tropical forest region of Africa seems to be marked out nearly by a line passing from the Albert Lake to beyond Lake Tchad, thence southward and along the western edge of the plateau to the valley of the Congo River, from that to the Zambezi valley, and from the lower course of that river northward again to the western sides of the Tanganyika and Albert Lakes.

NORTHERN LOWER LAND.

Northern fertile Belt.

The equatorial part of the lower land of North Africa, from below the lake region westwards, is occupied by densely populated negro states, and seems to be characterized by great fertility, and to form a belt of transition between the luxuriant growth of the forests of the plateau south of it, and the arid deserts on the north. It is partly wooded, partly cultivated in corn and cotton fields, and partly open pasture land. The plains of the Benue River are specially rich and fertile, and support large herds of cattle.

Lake Tchad is a shallow freshwater lagoon 830 feet above the sea, which receives the waters of large rivers from the south and west, but has no outlet, its surplus waters being carried off by evaporation. It is of very variable extent, being smaller in summer, and at its highest inundation in the end of October and during November. The level country which surrounds it is fertile and well wooded.

Sahara Desert.

From a line drawn from Cape Verd round the northern bend of the Niger and thence past the north side of Lake Tchad, on a parallel to the east coast, to the plateau of Barbary on the north, and from the Red Sea to the Atlantic, the whole of North Africa may be considered as one vast desert, the greatest on the surface of the globe. With the exception of the Nile, this vast area, of an extent greater than the whole of Europe, has no rivers and no water, save in a few distant wells or springs, the greater part of it being rainless. It has few inhabitants; many large areas in it are completely uninhabited, and is in most part covered with drifting sand-hills or stony plains; but throughout its extent are scattered 'wadis' or 'oases,' depressions in the desert, in which a little herbage, or a few trees, refresh the eye of the traveller. On its southern edge, the desert merges into the pasture lands of the Central African States.

The plateau of Air, or Asben, to north-west of Lake Tchad, is a mountainous table-land, reaching from 4000 to 5000 feet in elevation. It is an exceptional part of the desert, in which heavy tropical rains occur, and from this cause its valleys are rich in trees and vegetation, and its elevated plains have good pasture.

From the Mediterranean coast, between Tripoli and the plateau of Barbary, over the continent, to near the Senegal River on the Atlantic coast, a great belt of arid sand hills, or dunes, called '*El Erg*,' stretches unbroken for more than 2000 miles, averaging perhaps 200 miles in breadth. The plain of Senegambia continues it on the south-west. A great area of a similar character occurs midway between the Mediterranean at Tripoli and the plateau of Asben, and separating these two regions of sand dunes is '*El Hammada*,' a great uninhabited, sterile, and stony table-land. To north-west of the plateau of Asben, and between it and the sandy belt, is a wide depression in the desert, called '*El Djof*,' full of rock salt.

Great depression of the Libyan Desert.

The eastern part of the Sahara is termed the Libyan Desert, but the greater part of it is completely unpenetrated. In the northern part between the Hammada Plateau on the west, and the higher lands on the coast, there is a great depression in the desert, extending to near the valley of the Nile. The western part of it, recently explored by the traveller Rohlfs, was found by him to be everywhere from 100 to 150 feet below the level of the Mediterranean: the eastern part of the depression, has also been found by M. de Lesseps, from the Egyptian side, to be much beneath the level of the Nile, so that this part of Africa presents perhaps the greatest extent of land on the globe which is below sea level; and if a canal were cut into the depression from the gulf of the south of the Mediterranean, an inland sea would be formed in the Libyan Desert, perhaps not less in extent than the Caspian.

Nile Valley.

The valley of the Nile is the great natural highway into the equatorial region of Africa. It drains a great part of the equatorial regions of the continent, and the whole of the plateau of Abyssinia; but in its passage through the desert it is a single river, receiving no tributaries. The head of the Nile valley, immediately below the southern plateau, and between the White Nile and its tributary the Bahr el Gazal, is a region of many rivers, with marshy banks and thick woods between, in which, during the rainy season, the rivers swell out into wide lagoons.

A narrow strip of fertile land follows each bank of the Nile through the desert, and its annual inundation, caused by the rains in the plateau of Abyssinia, carries down the abraded soil of that plateau to fertilize the delta[1] in Egypt.

Plateau of Barbary.

The plateau of Barbary is a highland, which stretches through Tunis, Algiers, and Marocco, from Cape Bon in the Mediterranean, in a south-westerly direction to the west coast of Africa, in the latitude of the Canary Islands. The eastern part of it, in Algeria and Tunis, rises in a broad plateau from 2000 to 3000 feet in general elevation, with outer enclosing heights at an average of 100 miles apart; but in the west, i Marocco, these outer heights in closing, rise to a greater height, and the northern ridge forms the range of the Atlas Mountains, which attain the height of 11,000 feet in Jebel Miltsin. This plateau is a region of bushy steppe, and in the central hollowed part of it are numerous salt marshes of variable extent. The gentler slope of this plateau towards the interior, to as far as the belt of sand hills, is termed the Algerine Sahara, or country of date palms. It is not properly a desert, for it has abundant pasture, excepting when the land is dried up in summer.

In the eastern part of this region there are also numerous salt lagoons, and one of these, to the south of Tunis, is nearly 100 miles in length and 10 miles in breadth. In summer this great lagoon is dried up, and the central part of it is found encrusted with salt, but in winter it is covered with water to a depth of two or three feet.

The steeper slopes of the table-land of Barbary to the Mediterranean, and the broader coast land of Marocco, between the Atlas Mountains and the Atlantic, are the most populous and best cultivated parts of North Africa. This water-shed, which has numerous considerable rivers, is called the '*Tell*,' or cultivated land.

The coast lands of the east, to northward of Zanzibar, have numerous wooded plains, abounding in wild animals; and further inland, between this and the edge of the plateau, on which Mounts Kenia and Kilima Ndjaro rise, is a vast grassy plain, dry from November to March, but having abundant water and streams for the rest of the year.

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[1] See Map 18.

Bushy plains seem to line the greater part of the coast as far as the Red Sea; but between the edge of the Abyssinian plateau and the Red Sea is a wide desert, with frequent salt plains and salt lakes.

The coast land to north of the Gulf of Guinea is characterised by great lagoons communicating with the sea, and by marshy tracts between these, thickly wooded with palms.

Madagascar.

The Island of Madagascar is traversed throughout its whole length by a lofty range of mountains, whose summits rise to 11,000 feet in the centre of the land. On each side, the water-shed of this range has numerous rapid rivers. A great part of its coast land is low and swampy, but the elevated plains of the interior of the island are very fertile and populous, and in these all kinds of tropical grains and fruits are cultivated, whilst large areas are covered with forest trees of great size.

Rivers of Africa.

The hydrography of Africa is peculiar.[1] No other continent has such a great region completely destitute of rivers, and yet close beside the area, notable for this want, flows the Nile, one of the greatest rivers in the world. Only three of its great rivers could be used as natural openings for traffic into the country. The Nile drains nearly one-tenth of the whole area of the continent; its navigation is impeded by six cataracts in its middle course; but with these breaks the White Nile is probably passable for vessels to within five degrees of the equator, after which there are several falls in its course. The Niger, the second river of Africa, has been ascended for more than 500 miles, and its tributary, the Benue, for 350 miles from its confluence. The Congo River rushes out into the ocean with a strong current. At 140 miles from its mouth, narrows and cataracts begin and extend for 40 miles, but beyond these, it might be navigated for 100 miles without impediment. The Zambezi drains a great part of the eastern side of the continent, but has a rapid fall, and a bar at its principal mouth unfits it for commerce. The Orange River is innavigable, owing to the variableness in the depth of its current.

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[1] Map 15.

AUSTRALASIA.

MAP 10.

THE name Australasia is properly confined to the groups of Islands in the Pacific Ocean, east of the 130th meridian, and between 30° N. and 50° S. latitude, including the greatest of all islands, or the smallest of continents—Australia.

The map of this region in the Atlas includes the larger of the East India Islands, which politically belong to the division of Asia, though geographically they form a part of the island quarter of the globe. The area included is traversed by a part of the great belt of volcanic disturbance which surrounds the Pacific, and indeed contains the most active and terrible part of this circle. The line of this belt passes from Mount Erebus, in the antarctic region, through the north island of New Zealand, and Papua, to meet the circular line of greatest disturbance, a branch of the main belt, which winds through the Greater and Lesser Sunda Islands, from Sumatra and Java, to the chain of smaller islands east of these, across the Banda Sea to Ceram and Gilolo, and thence with the main belt through the Philippine Islands, round the east coast of Asia. These lines then surround the two largest islands of Australia and Borneo, which seem to be undisturbed by subterranean fires.

The Malay Peninsula, the link between this island division and continent, is only united to Asia by the narrow Isthmus of Krah. It is traversed in its centre by a high mountain range, which rises in some parts to above a mile in height, and slopes down to the lowland next the coasts, which becomes swampy on the side of the Gulf of Bengal. The country is generally covered with trees of great variety.

Volcanic circle of the EAST INDIES.

The island of Sumatra has a mountain region on the south-west and a level plain on the whole of the north-east side. Its mountain ranges run parallel with the western coasts, and inclose high table-lands; several of the summits are volcanoes, amongst which, perhaps, the highest is Mount Ophir, 13,840 feet. These ranges are generally covered with dense forest. The plain to the north-east is low and well cultivated, but the central part of the eastern coast is a thickly wooded swamp.

Java.

Java is, for the most part, a high table-land, sloping steeply to the sea on the south side of the island, but less suddenly on the north, to a plain which runs along the whole of the island next the Java Sea, and terminates in a swamp on the west. Very numerous volcanic peaks rise from the table-land to a great height, and the summit of the island, *Mount Semeroe*, is 12,235 feet in elevation. Java has a rich soil, and cultivation of all tropical products is carried on in the warm lowland and higher temperate region of the island, to an average elevation of 4000 feet, and trees occupy the higher mountains to an elevation of 7500 feet.

In the chain of the Lesser Sunda Islands to the east of Java, the island of *Sumbawa* has a mountain range next its south coast, in which is the volcano of *Tomboro*, 9040 feet in elevation, whose eruption, in 1815, is perhaps the most terrible on record. The island of *Floris* has also several high volcanoes, and *Timor* Island, the largest of the chain, is formed by a very lofty range of mountains. Following the volcanic belt, we pass through the Banda Sea to the Moluccas, or Spice Islands, to the lofty island of Ceram, which has a range of mountains rising to between 6000 or 8000 feet above the sea, clothed with luxuriant vegetation and gigantic trees; and Gilolo Island, curiously similar in shape to the larger island of Celebes, to the west of it, with densely wooded mountain ranges. This island is near the point of junction of the volcanic circle of the East Indies with the belt which surrounds the Pacific Ocean.

The whole group of the Moluccas is elevated, and of volcanic origin, numbering several active volcanoes. To northward the volcanic belt passes next through the Philippine Islands. The southmost of these, the Island of Mindanao, has wide tracts of grassy savannah, though the central parts are hilly, and contain several volcanoes.

Borneo.

Borneo, the largest island on the globe, excepting Greenland, if Australia be considered as a continent, has an area greater than that of the empire of Austria. It lies within the East Indian volcanic circuit, directly under the equator, and has a great mountain system, running nearly at right angles to the direction of the ranges of Sumatra and Java, on its western side. From a central knot in the range, branches diverge to east and south-east, dividing the lower country into separate basins, in which are numerous rivers, navigable to a considerable distance from their mouths. The highest known point is Mount Kini Balu, 13,698 feet, in the northern corner of the island. The climate of Borneo is very moist, the greater part of the country is covered with wide forests, and it abounds in vegetable products.

The island of *Celebes* is remarkable in its form. From a central mountainous tract in it, four arms branch out to form the high peninsulas of the island. The lower parts of the island have extensive grassy plains, and the land generally is fertile, though timber is not abundant.

Papua.

The long Island of Papua lies parallel to the volcanic belt of Sumatra and Java. It consists of a wide mainland, terminating at each end in a peninsula, that on the west of the island being only united to it by a narrow isthmus. In the main body of the island there appears to be a high central ridge of mountains; but the country between the mountains and the sea, so far as it has been seen, is low, with extensive swamps, and forests of lofty trees. The eastern peninsula of Papua is a chain of high mountains, one of which, Mount Owen Stanley, rises to 13,205 feet. Near its coasts is a chain of small islands, with several active volcanoes.

The Islands of New Ireland and New Britain, in a chain which lies parallel to the Island of Papua, are high and wooded, and smoke has been observed to issue from one of the peaks of the latter island. The chain of the Solomon Islands, continuing the direction of New Ireland, is generally mountainous, with steep and rugged shores. The hills are wooded, and between are fertile valleys. Further south, in the line of this group, is the chain of the New Hebrides, consisting generally of hills of moderate elevation, with fertile valleys and coast plains. One of these islands has an active volcano.

New Caledonia is a long narrow island, also lying in the same north-west and south-east direction, which characterises the higher parts of this region. It is completely surrounded by coral reefs. A mountain range passes along the centre of the island, rising from 2000 to 3000 feet above the sea. The island is less fertile than most others in the Pacific, and the slopes of the hills are covered with coarse grass and a few trees.

Viti and *Vanua Levu*, the main islands of the Viti or Fiji group, are high table-lands, with steeply sloping sides, but have occasional well-wooded plains between the base of the mountains and the sea-coast. The group of the Friendly Islands is low and fertile.

NEW ZEALAND.

The Islands of *New Zealand* form a group of two larger and one smaller island. In these the line of elevation seems to change its direction from that of the East India Islands to one from north-east to south-west, as is also observed in the mountains of the east coast of Australia. The two larger are known as the North and South Islands, and the smaller, Stewart Island, lies off the southern end of the South Island.

North Island.

The North Island of New Zealand differs, both in form and character, from the South Island. The main part of it is in the form of a rudely drawn square, with a projection to south and northward on the eastern side of it, and a long peninsula, stretching to the north-west from it, united by a narrow isthmus, in one part only a mile in width. Its central point, Mount Ruapehu, 9195 feet, is the highest summit in the island. Two ranges of from 2000 to 3000 feet in height. run parallel to the coast on the eastern side, and the remainder of the island appears to be an uneven table-land approaching nearly to this elevation, except where, in the western corner of the main part of the island, Mount Egmont rises alone to 8270 feet. The north-western peninsula appears to be generally elevated, and rises, in some points, to above 2000 feet. The north island seems to be in great part of volcanic origin, but the south island has no evidences of recent volcanic action. Mount Tongariro, is an active volcano in the centre of the North Island, next to Mount Ruapehu, which is an extinct cone. Mount Egmont, in the west of the island, is also an extinct volcano; and the Isthmus of Auckland is thickly studded with minor extinct craters. The south island, on the contrary, has one continuous mountain ridge throughout its length, of an average height of perhaps 6000 feet, and rising, in the centre, to 13,200 feet in Mount Cook.

South Island.

The highest part of the range lies uniformly more to the west than the east coast, sloping towards the latter in minor ranges, which generally lie parallel to the main chain. These lower ranges reach down to near the sea, on all sides of the island, thus forming a steep and lofty coast, excepting where there is a level and treeless plain on the east side of the island, between the high projection of Bank's peninsula and the base of the mountains; and in the centre of the south part of the island, the plain of the Oreti River, reaching the coast opposite Stewart Island.

These islands together form an area considerably larger than that of the island of Great Britain, though not so great as that of the British Isles; and New Zealand has been termed the 'Britain of the south.' These two groups of islands, in the opposite hemispheres and nearly antipodal to one another, have a very similar climate in their winter and summer; but though the mineral products of New Zealand are extensive and valuable, yet the nature of the country prevents the possibility of great commercial extension. The rivers are numerous, but the rapidity of their fall, and the sudden variableness of their volume, precludes navigation, and the same highland nature of the country would interfere with the construction of railroads or canals.

Tasmania.

The Island of Tasmania, a pendant to the continent of Australia, balancing the peninsula of Cape York on the opposite eastern extremity, is a high table-land, sloping down on all sides to the coasts. The outer edges of the highland are supported by mountains of from 4000 to 5000 feet in height; and Mount Humboldt, on the western side, the highest point of the island is 5520 feet above the sea. The soil is generally fertile, and the mountain region, especially in the west, has immense forests.

The physical geography of AUSTRALIA is remarkable, and completely different from that of any of the larger continents.

AUSTRALIA.

An irregular line drawn round the interior of the continent, embracing about a third part of its area, marks the division between the coast region draining to the sea, and the vast interior basin, from which no water escapes to the ocean. This line also marks the boundary between the more productive and valuable outer margin of the continent, and the more sterile and desert region of the interior.

In general, Australia may be considered as the lowest of the continents. The highest land of the continent, and the only considerably elevated part of it, is a series of mountains and hill ranges which rise close to its eastern coasts. Its eastern side thus presents a steep slope to the sea. Behind these ranges, especially in the south, the slope is gradual to the channel of the Darling and Murray Rivers, and the upper terraces of this descent form the vast pasture lands called 'Downs.' The highest part of the eastern heights is in the south, in the Australian Alps, where Mounts Hotham and Kosciusko rise to above 7000 feet: the Blue Mountains, further to the north, appear to have a general height of about 3000 feet; and the Liverpool range, which runs transversely to the coast line, rises to about 4000 feet in general elevation. In the centre of the east coast,

Outer margin of Pasture Lands.

at the corner where it turns from the north-easterly to a north-westerly direction, Mount Lindsay attains 5700 feet; but beyond this, to the northward, the mountains never exceed 4000 feet in height, and decrease to less than 1000 feet as they approach Cape York.

The greatest break in the shores of Australia, which resemble those of Africa in their general roundness, is that of the Gulf of Carpentaria. Its shores are low and flat, covered with mangroves, but inland from the south of it are the grassy 'Plains of Promise,' with clumps of gum trees, continuing the 'downs' of the east round the northern side of the continent.

Further west, the central projection of the north coast of Australia seems to have more the character of a table-land, of from 2000 to 3000 feet in elevation, with wide grass lands. The north-west coast land has not yet been penetrated by explorers, and, indeed, the whole western half of the interior of the continent is completely unexplored. The more northerly part of the north-west coast is bold, with granitic and basaltic headlands, but the more southerly portion is low and sandy.

The northern part of the western margin, so far as it has been explored, seems to rise from a high coast line, in fertile grassy terraces and plains, watered by numerous streams towards the water-parting, which lies at a general distance of from 200 to 300 miles inland. Several summits in the interior of the region reach a greater height than 3500 feet.

In the southern part of Western Australia the mountains approach close to the coast line, forming a steep edge to the sea, and supporting wide table-lands in the interior, which, near the coast, have extensive rich grassy plains, but inland are characterised by shallow salt lakes and swamps, or their dried-up beds, and by sandy plains. The general height of these plains is, perhaps, from 800 to 1000 feet; but many of the higher points rise to double this height, and one peak on the south-west coast range is 3600 feet in height. The desert country of the interior extends to near the south coast at Cape Arid, between which and Spencer Gulf, extends the great Australian bight, with a completely riverless coast, and apparently a totally desert region towards the interior of it. The coast of the bight rises from 300 to 400, and even in some parts to a general height of 600 feet close to the sea. The peninsula on the west of Spencer Gulf is more hilly and broken, and one point of it, on the shore next the gulf, rises to 2000 feet. Beyond Spencer Gulf, and the the smaller inlet beyond it, to the eastward a long series of parallel ridges of hills, known as Flinders range, extends inland at right angles to the coast for nearly 300 miles, and its summits reach an average height of 3000 feet. In the lower course of the Murray River, the deserts and salt plains of the interior reach down to near the south coast, but the slopes of the hills extending westward from the Australian Alps, especially that one which faces the sea, are the most cultivated and populous parts of Australia.

Interior Desert.

The interior of the continent, marked out by a line connecting the source of the rivers which reach the sea, may be considered as an almost complete desert, and we have seen that this desert reaches quite down to the south coast of the continent, within the Australian Bight. It occupies exactly the same relative position in the southern hemisphere of the globe as the great Sahara of Africa does in the northern; the tropic of Cancer passes through the midst of the one, and that of Capricorn through the other; and we have seen in the Notes to Maps 3 and 4 that it is just in this outer part of the equatorial region, or under these boundary lines of the tropics, that the sun's scorching vertical heat is felt for the longest period. The moisture brought by the northerly monsoons, which are drawn towards the continent in summer by the ascending current caused by the vertical sun's heat, is expended on the northern margin of the continent in the *summer rains;* but these do not penetrate for more than 200 or 300 miles on an average from the coast. A rainless summer characterizes the rest of the continent, and the *winter rains* from the south do not seem to be experienced beyond the 30th parallel of latitude. This interior desert has been supposed by some to be the bed of a sea of recent date; and a great district of salt lakes in the south of it, would seem to bear out this conjecture. Lake Eyre, the largest of these, is a great shallow and swampy lake of variable extent, and with salt encrusted shores. Its height above the sea has been found to be only 70 feet,[1] and its area is estimated at 4100 square miles, or nearly three times that of the great Salt Lake of America. Lake Torrens, which is perhaps at a less height above the sea, is not properly a lake, but an extensive depression, with great shallow salt pools, surrounded by sand hills, strewn with boulders. Though only separated by a narrow isthmus of about 12 miles in breadth from the narrow head of Spencer Gulf, yet there is no communication between them; and none of the lake-beds in this region have any outlet.

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[1] Babbage.

North of this region of salt lakes, and near the centre of the western interior, is the '*great stony desert*,' an undulating plain, thickly and uniformly strewn with boulders, sometimes interspersed by shallow hollows in which water collects, extending over more than 3000 square miles. MacDowall Stuart's solitary route across the centre of the continent, proves that there is no great elevation in the interior. It proceeds over occasional sandy hill ridges, and through great stretches of scrub or bushy jungle between these. Next to the central region of Africa, the eastern part of the interior of Australia is the largest unexplored land region of the globe. Every where that the water-parting line has been crossed into this interior region from the north or west, the same sandy desert, waterless plains, salt lake beds, or scrub, have arrested the traveller's progress; and to southward we have seen that the desert reaches to the sea coast.

Coral Sea.

Many of the islands and island groups in the Pacific are the work of the coral insect, but the chief centre of the industry of this animalcule seems to be the coral sea, between the Island of Papua and the north-eastern coast of Australia, which has innumerable coral reefs and banks; the most remarkable extent of coral in the world is the Great Barrier Reef, which extends along the whole north-east coast of Australia, and leaves a long deep open channel between it and the coast.

HYPSOMETRICAL MAPS OF THE BRITISH ISLES.

MAPS 11 and 12.

THESE Maps are intended to show the leading physical features of the British Isles, and of the sea bed out of which they immediately rise, their highlands and plateaus, their plains and valleys. The method adopted to show these features is that of Contour lines. the length of an English mile being taken as the standard measure for this throughout the Atlas, the lower heights of the land and lesser depressions of the sea bed being indicated by lines of parts of a mile of equal height or depth.

Thus, the line on the Map which is nearest the coast indicates an equal height of one-sixteenth of a mile (330 feet) at every point over which it passes; the second, an equal height of one-eighth part of a mile (660 feet); the third, one quarter of a mile (1320 feet). Each line becomes more and more broken up as it ascends, till the heights above half a mile (2640 feet), in the British Isles, can only be indicated by a series of scattered points. The same system has been carried out in representing the depths of the sea bed surrounding the islands. The first line outside the coast passes through every point which has a depth of one-sixteenth of a mile, and the succeeding lines mark out depths of one-eighth, one-fourth, one-half, and as much as one mile off the west coast of Scotland.

If we could imagine the water of the sea to rise to the height of only one-eighth part of a mile above its present level, the whole of Central England and Ireland would be submerged, leaving an archipelago of islands, in which the Welsh mountains and the Pennine Chain would be prominent, and Scotland would form three separate islands, the largest in the supposed group. Again, if we conceive the sea water to be drained off to the depth of one-eighth part of a mile, Great Britain and Ireland and the isles surrounding them would no longer be insulated, but would become parts of the continent of Europe joined to it by the great plain which now forms the bed of the North Sea and the English Channel, in which plain the Dogger Bank would rise, as the Lincoln Wolds do from the plain of York, and the then sea coast would be formed by an even line, when compared with the present ragged coasts, at a general distance of about 50 miles beyond the Hebrides and Ireland. The British Isles rise on a submarine plateau, whose edge leaves the continent at the south-eastern angle of the Bay of Biscay, extends thence to north-west at a distance of about 100 miles from the French coast to the same distance from the Scilly Isles off Land's End, and passes round Ireland, the Hebrides, and the Shetland Islands, at an average distance of 50 miles from these coasts; its outer slope then stretches to about a hundred miles to the north-east of the Shetlands, and turns sharply to south-east, keeping away from the coast of Norway (round the south-west coast of which there is a deep valley in the sea bed with a general width of 50 miles), to where it rejoins the continent in the entrance to the Baltic between the south cape of Norway and the Swedish coast. Over the whole of this plateau there is a less depth of water than one-eighth part of a mile, excepting two small areas of greater depth in the North Channel, one of which is in the centre of the strait which separates Scotland and Ireland, and the other just to the north of Rathlin Island; and a third submarine valley between the Islands of Barra and Tiree, off the Scottish coast, lying in the same direction as the Great Glen of Scotland. The sides of this plateau, which face the Atlantic, slope off very suddenly into the depths of that ocean. The part of this declivity which lies off the west coast of Scotland comes into the corner of the Map, where we observe that the fall is rapid to below one mile in depth, at a distance of 120 miles from the coast. If we could imagine ourselves standing at the base of this plateau, we should then look up to the top of Ben Nevis, 10,000 feet above us.

In a general view of the island of Great Britain it is observed, that the higher lands are to the north and west, the lower to the south and east.

Highlands of Scotland.

The Highlands of Scotland form three distinct divisions completely separated from each other by lowland valleys. These are the *Northern Highlands*, occupying the whole of that part of the country which is cut off by Glen More, then the *Central Highlands* of the Grampian ranges, with the greatest general height of any part of the British Isles, and the *Southern Highlands*, separated from the central group by the lowland valley of the Rivers Forth and Clyde. The ranges of mountains, which form these highlands, take that general direction from south-west to north-east, which is observed to prevail more or less throughout the British Isles.

The district of the *Northern Highlands* is the most uncultivated portion of Scotland, being almost entirely a moorland district, thinly populated, and partly affording pasture for sheep, partly preserved as deer 'forest.'[1] Its highest point is perhaps Ben Attow, 4000 feet, in the south-west of the main range.

The *Central Highlands* are also moorland districts covered with heather, and for the most part used only as deer 'forest;' but the valleys and the coast lands on the north-east are more cultivated. The highest point of this district, and of the whole of the British Isles, is Ben Nevis, 4406 feet above the sea, on the western side of the highlands; and the second, also the second highest mountain of Britain, is Ben MacDhui, 4296 feet, at the sources of the River Dee, on the eastern part of the Grampian range. Only one large part of the ancient forest of Scotland is still remaining, on the western slopes of the Ben MacDhui group, towards the valley of the Spey, the pine woods of Rothiemurchus.

The Lennox, Ochill, and Sidlaw Hills, are outliers of the Grampian range, separated from it by a broad valley.

The *Southern Highlands of Scotland* are broken into on all sides by cultivated valleys, but the higher grounds can only be used as pasture lands. The highest point of these is again in the south-west, where Mount Merrick rises to 2764 feet.

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[1] This term 'forest' is now a misnomer, since the trees, which may at one time have covered the highlands of Scotland and justified this name, have long been cut down, and almost all traces of them have been removed, excepting in one part afterwards mentioned.

Highlands of England.

The *Cheviot Hills* are nearly separated from the Southern Highlands by the upper valleys of the Solway and Tweed, and they form the northern termination of the *Pennine Chain* of England, which stretches due south from these into the heart of England, composed of an irregular series of ridges running at an angle to the general direction of the range. It is entirely a moorland district, covered with grass and heath, and affording excellent sheep pasture. The highest point is Cross Fell, 2900 feet, in the centre of the range. To the west of the Pennine Chain is the group of the *Cumbrian Mountains*, in which the highest mountains of England rise, Scawfell, on the west of the group, being 3280 feet in height. The *eastern moorlands* of Yorkshire are much lower, though of the same mountainous character as the western. In the south, these lower eastern heights are continued in the '*Wolds*' of Yorkshire and Lincoln, forming a part of the chalk formation, which extends from the cliffs of Flamborough Head to the south of England. Those wolds have their steepest escarpment on the west, and slope gently to the coast on the east. The highest and most rugged highland of South Britain is that of the *Cambrian Mountains, in Wales*, a region of moorland pasture, uncultivated except in the southern part of the coast-land next the Bristol Channel, separated from the lower lands by the vale of Severn and the plain of Chester. The highest point of the Cambrian Mountains, and of South Britain, is Snowdon, 3590 feet, in a lofty range which extends over a N.E and S.W. direction in the north-west of the district. On the southern side of the Bristol Channel, the western heights of South Britain are continued in *Exmoor* and *Dartmoor*, and terminate in the *heights of Cornwall;* the highest point of this southern group is Yes Tor, in Dartmoor, 2050 feet.

The *central* part of England is a *plateau* rising from 300 to 400 feet above the sea, extending in continuation of the Pennine Chain between the vale of the Severn on the west, the plains on the east, and the valley of the Thames on the south, and rising higher in the south in the *Cotswold* and *Chiltern Hills*. A part of it is occupied by the manufacturing district of England. The district between the valley of the Thames and the south coast is occupied by an upland of an average height of 300 feet, having higher enclosing chalk lands on the north and south, known as the *North and South Downs*. The Downs rise in an undulating surface to an average height of 500 feet, and reach the coast to form the chalk cliffs of Beachy Head and the North and South Forelands. Enclosed by the Downs is the '*Weald*,' an agricultural district, once an immense forest, and still partly wooded. To the westward, this upland district is continued in the *Marlborough* and *Ilsley* chalk downs, with occasional higher parts, to Salisbury Plain, a wide level chalk plateau, about 400 feet above the sea, uncultivated, with scanty herbage and little wood. From this, the Downs continue to the south westwards, into Dorsetshire, the heights rising to the west in *Black Down*, and afterwards merging into the western moorlands. The south part of the Isle of Wight is a high chalk down, falling steeply in cliffs to the south, but sloping gently to the northward.

Valleys and Plains of Great Britain.

The north-east corner of Scotland is occupied by an uneven moorland known as the *plain of Caithness;* it is bounded inland by the northern highlands.

Glenmore, or the Great Glen of Scotland, is a narrow valley running in a strait line across the country from south-west to north-east, and separating the northern from the central highlands. In it are three lakes united by a canal, the chain being known as the Caledonian Canal, which thus completes a water communication across the country from the North Sea to the Atlantic. The highest part of the canal is 94 feet above the sea, in the central lake.

A fertile and well cultivated plain lies between the central highlands and their outliers to the south. The eastern part of this plain, between the Grampian Mountains and the Sidlaw Hills, is known as *Strathmore*, the word *strath* meaning a wide open vale as constrasted with a narrow valley or *glen*. The '*Lowlands*,' separating the central and southern highlands, extend between the Firths of Forth and Clyde, and are naturally the best cultivated and most thickly populated parts of Scotland. The rich agricultural belts, which stretch along the lower courses and estuaries of the Forth and Tay, formed by alluvial deposits from these rivers, are called the '*Carses*' of Stirling, Falkirk, and Gowrie.

Further south is the *valley of the Tweed*, rendered fertile by industrious husbandry; and on the opposite side of the island, the lowlands, which border the Solway and extend into the *vale of Eden*.

The '*Plain of York*' is a large lowland area watered by the rivers Ouse and Trent and their tributaries, extending from the base of the Pennine Chain on the west to the eastern heights of York and Lincoln, reaching northwards to the sea coast at the mouth of the Tees, and southward to the central plateau of England, and sloping gently, in fertile lands, towards the marshy flats and levels of the lower Ouse.

To the south of this is the *Fen district*, between the Welland, Nen, and Great Ouse rivers, a district reclaimed from the sea by embankments and drained by numerous canals, believed to have been a dense forest at the time of the Roman invasion, and afterwards a morass, through inroads of the sea. The marshes are estimated to occupy more than 600 square miles, the drained parts being covered with cornfields and pastures.

The *Eastern Plain* is the undulating country which extends between the Wash and the estuary of the Thames. consisting. in great part, of arable land. On the north-west side, facing the valley of the Ouse, the chalk downs form the highest part of the plain, which subsides gradually thence towards the east, where, in their lower courses, the rivers flow through flat marshy valleys, and form broad pools called '*meres*.' Continuing the eastern plain to the southward, is the opening of the valley of the Thames. This valley contains some of the richest agricultural districts of England. The lower district is of considerable breadth, but it is narrowed in its upper part between the Chiltern Hills on the north, and the Downs on the south of the river course.

The *Plain of Cheshire* and the valley of the Severn separate the Cambrian Mountains from the Pennine Chain and the central plateau of England. It is a nearly uniform level, which formerly was covered by forest, and a few large woods still remain. The surface is sprinkled with numerous sheets of water or '*meres*.'

The plain is continued into Lancashire northwards as far as the mouth of the Ribble, in a flat belt from the base of the Pennine Chain to the sea coast, containing extensive peat mosses; and to the southward it joins into the narrow *vale of Severn*, which continues the lowland to the Bristol Channel.

Mountain Circle of Ireland.

The Contour Map of Ireland presents the leading general features of a number of groups of mountains more or less completely surrounding a central plain. Though the summits of some of these surrounding groups rise to nearly the same average height as the mountains of England, yet from their more scattered and broken nature, the areas of great general elevation are small in Ireland when compared with those of Britain. Three *northern groups* are the Derryveagh, Sperrin, and Antrim Mountains, separated from each other by the Rivers Foyle and Bann. The highest point of these groups, Mount Errigal, 2466 feet, is in the west, like the culminating points of the highlands of Scotland and England. On the eastern side of the island are the Mourne and Wicklow Mountains, separated from each other, and from the sea coast to the north and south of them, by lower lands. The highest point of the Mourne Mountains is Slieve Donard, 2796 feet, but the group only occupies a small area. On the other hand, the Wicklow Mountains form the highest and widest mass of land in Ireland, though they have not the highest summit, Lugnaquilla being only 3039 feet in elevation. The groups of the Comeragh, Galty, Knockmealdown, and Kerry Mountains, form a barrier on the south of the island, divided by the courses of the larger rivers. The highest point of these groups and of Ireland is *Carrantuohill*, 3414 feet above the sea, also in the west of the highland. Lesser heights on each side of the mouth of the Shannon, continue the outer barriers of the central plain on the west to the higher mountains on the coasts of Galway and Mayo, where several summits attain an elevation of above 2500 feet; and another coast group, whose highest point is Cuilgach, 2188 feet, unites the western to the northern heights. Mount Keeper and the Slieve Bloom, which form the water-parting of the tributaries of the Suir and Shannon, are outliers of the southern group of mountains.

Plains of Ireland.

The *northern* part of the great plain of Ireland is the lowland which extends round Lough Neagh, embracing the area which drains into the lake and the valley of the Bann, between the lake and the sea. The *central plain* of Ireland is the country watered by the Shannon and its tributaries, lying chiefly to the left of the river course. It is characterised by frequent marshes or *bogs*, which occur especially in the lower districts next the rivers and lakes; but the higher lands have a rich soil, producing heavy grain crops, and affording the finest pasture. The head waters of the basin of the Erne connect the central with the northern plain of Ireland; and the valley of the Erne, with its lakes, forms a branch from this to the north-west. The *eastern* part of the plain comprises the basins of the Boyne and Liffey, and the head waters of the Barrow. The greater part of it is rich grazing land, with a gently undulating surface; but in the south-west, where it joins into the central plain, at the head-waters of the rivers which flow west, south, and east, is the most continuous bogland of Ireland.

The largest of these bogs, known as the *Bog of Allen*, covers an area of about 350 square miles, and is at an average elevation of

250 feet above the sea. To the west of the central plain, and separated from it by the line of low elevations which form the water-parting between the tributaries of the Shannon and the, drainage to Loughs Mask and Corrib, is a flat boggy area, which may be called the *western plain* of Ireland. At the south-west corner of the central plain, the valley of the Shannon is narrowed by the enclosing heights, but afterwards the country opens out on each side of its estuary to south and north, in the 'corcasses,' or rich hollows, of the *plain of Limerick*, which yield the heaviest crops in Ireland, and in the lowland between the mouth of the Fergus and the western plain of Ireland. The sloping lands, which border the sea-coast on the south of Ireland, from Wexford to Cork, and the banks of the river stretching inland from these, are fertile and productive.

Temperature of the British Isles.

The British Isles are situated in the northern part of the temperate regions of the globe, but enjoy a milder and more equable climate than any other land of the northern hemisphere in the same latitude. This is due partly to their being surrounded by the ocean, which, retaining a more uniform temperature throughout the year, is able to give off a portion of its warmth to the land during winter, and to moderate its heat in summer; and partly for the reason of their position off the *west facing* coast of a mass of continental land,[1] upon which there is a prevailing tide of moist south-westerly wind across the Atlantic from warmer latitudes, only interrupted to any considerable extent in spring, when, on the first turning of the northern hemisphere towards the sun, the great land area of Northern Africa becomes more heated, causing an upward current there, which draws the dry continental air southward through Europe. From the turning of the earth below this cold southward current, the wind appears to come more from the east or north-east when it reaches the British Isles.

January.

No part of the British Isles has a lower average temperature in January than 37°, and none higher than 45° Fahr., this latter temperature being confined to the small corner of the land of Great Britain which lies farthest to the southwest. Ireland has a milder temperature in January than Great Britain, the average temperature of the interior of the latter being 37°, whilst a line of 40° Fahr. surrounds the same relative portion of Ireland, and the lowest temperature there is 39°. This temperature of 39° is also that of the whole west and south coasts of Scotland and England in January, from the Orkney Islands to the Strait of Dover. We may then compare the January temperature of the British Isles with that of the Southern States of North America, or with Central France, Turkey, or the lower Caspian, the middle of China, or the Islands of Japan. The last instance shows very clearly the advantage of a western aspect, since the British Isles on the west facing coast, in 55° N. latitude, have the same winter climate as the islands of Japan, which are in 40° N., or more than 1000 miles nearer the tropics, but are off the coast which has an eastern aspect.

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[1] See Maps 23 and 24.

July.

The average July temperatures of the British Isles are between 54° in the north and 64° in the central parts of the south of Great Britain, and these diminish more in accordance with the latitude northward, whilst the January temperature decreases more by easting. The July temperatures of the British Isles, owing to their insular position, are lower than that of the interior of the continents in the same latitude, though not so low as the corresponding coast regions which have an *eastern* aspect. Thus their temperature at this season is *higher* than that of the Labrador coasts, or those of Eastern Asia in the same latitude, but nearly 10° *below* that of the rest of the continents of America and Asia in the same zone.

The July temperature of Britain may thus be compared with that of the Hudson Bay territories, with Norway, or with Siberia, in much higher latitudes.

The modifying influence of the surrounding sea on the climate of the British Isles is seen in this—that the lowest temperatures in January are found in the eastern central parts of the island, the warmth *increasing* towards the coasts, the western especially; and that the highest temperatures in July also seek the interior of the country, *lowering* towards the coasts. This is noticed in the broadest part of South England, where an area stretching between London, Oxford, and Southampton, has the average July temperature of 64°, whilst the surrounding coasts have an average of one or two degrees lower. It must be understood that these isothermal lines do not represent the actual average temperature of every point over which they pass, but only the average temperature of every place on the line, *as if it were at the level of the sea.* Since temperature decreases, on an average 1° for every 300 feet of elevation,—to represent the actual average temperature of the highest parts of the country, would be to draw contour lines round the elevated districts, which, though they would give the correct local temperature, would not represent the general climate in latitude, since any degree of arctic cold may be obtained by a sufficient ascension, even in the tropics; but a correct estimate of the actual temperature of any elevated district in January or July, may be formed by observing its height above the sea, from the contour lines on the map, and by subtracting 1° for every 300 feet of this elevation from the temperature indicated by the isothermal lines.

The contour lines represented on the map have been worked out chiefly from the Ordnance Spirit Levelling Surveys of England, Ireland, and the northern parts of Scotland, at first on a much larger scale, afterwards reduced to this map; and the contoured maps of the one inch Ordnance Survey of Scotland have been used in laying down the lines for that country, as far as the Survey has been published. The depth contours have been adapted partly from the elaborate map of the British Isles and the surrounding sea, by Petermann, in Stieler's Hand Atlas, and partly from the Admiralty Charts. The isothermal lines have been laid down from those given in the map accompanying a paper on the Isothermals of the British Isles, by A. Buchan, Secretary of the Meteorological Society, published in their Journal for 1864; which lines were drawn from the observations made at 109 stations, calculated on a mean of the five years from 1857 to 1861 inclusive.

SYRIA AND THE ISTHMUS OF SUEZ.

MAP 13.

IF the Mediterranean area be the most interesting on the surface of the globe to the student of Physical Geography, it is in the eastern part of it, in the region surrounding the Levant, between the Nile Delta on the south, and the mountains of Asia Minor on the north, that this interest concentrates, since here we have a most complete and compact model country, with plain and table land, hill and mountain, valley and depression.

The Map of this region, which is given in the Atlas, has been worked out on the same scale as the Hypsometrical Maps of the British Isles, and the same system of contouring has been applied to each, though, from the greater heights of the land in Syria, a higher set of contour lines come into use.

North Coast of the Levant.

Enclosing the Levant on the north is the alpine region of the Taurus Mountains, the highest buttress of the plateau of Asia Minor. It is cut into by the valley of the River Gok, which winds between colossal cliffs of limestone, and in one of whose tributaries is the most famous pass of the range. Several peaks of the Taurus reach a height of 10,000 feet. Further to the east, between the lower courses of the Sihun and Jihun Rivers, is the fertile plain of Adana or Tchukur, producing abundance of fruit, corn, and timber. Next, the Gulf of Iskanderun, at the north-east corner of the Levant, cuts far into the land between the spurs of the Taurus. The range extending on the south of the gulf is the precipitous Alma Dagh, or Amanus, traversable only in a few places.

Central Valley of Syria.

Turning southwards from this corner the coast country forms a highland, which has been compared to an isthmus between two oceans, the Mediterranean on the one side, and the sea of sand, the desert, on the other. This isthmus is furrowed in its centre by a deep valley, which extends from the plain in the lower course of the River Orontes in the north, to the Gulf of Akaba, an arm of the Red Sea, on the south. The different parts of it have different names, but throughout its entire course it is enclosed by lofty mountains. The highest part of the floor of this central valley, where it is shut in by the Lebanon ranges, is about 4000 feet *above* the sea; and the lowest, at the bottom of the Dead Sea, 2600 feet *below* the level of the Mediterranean; so that the bottom of this remarkable furrow is in some parts at a greater elevation above the sea than the mountains which enclose it at others.

The northern part of this valley, the course of the Asy, or Orontes, is separated from the sea coast by the Jebel Nusaitieh. The steepest side of this range, covered with shrubs, is towards the river, but its western declivities to the sea are clothed with fine trees, with well cultivated valleys between the lower ridges. Its highest point is in the north, flanking the mouth of the Orontes, and rising to 5800 feet; and on the other side of the depression, through which the river escapes to the sea, at the southern extremity of the Alma Dagh, is one of its chief summits, 5172 feet in height. At the point where the Asy bends round to the west to reach the sea is the *Plain of Antakie*, or *Antiochia*, containing an extensive swampy lake. The upper part of this plain, watered by a tributary of the Asy, is well cultivated. To the south of this the valley of the Asy gradually narrows, and becomes enclosed by rugged mountains, but widens again in the neighbourhood of Hamah. The vast green valley of *Cœle Syria*, between the outer and inner ranges of the Lebanon, forms the central part of the great valley of Syria. Half of it is drained to the north by the head waters of the Asy, and half to southward by the Litany River. The water-parting is near the ruins of Baalbek, which are 3800 feet above the sea.

Lebanon.

Mount Lebanon, between the valley of Cœle Syria and the sea, is a continuous range of mountains more than 100 miles in length, and with an average elevation of 8000 feet. One point in the northern part of the range, capped with perpetual snow, reaches a height of 10,061 feet, and several summits rise above 9000 feet. The higher parts of the range are destitute of trees, but the narrow valleys and water courses of the lower western slopes, except a narrow strip on the sea coast, are thoroughly cultivated, with terraced groves of olives, vineyards, fields, and orchards. The eastern side of the Lebanon falls steeply towards the valley, and is furrowed by water courses; the lower parts are covered with low oak trees.

The range of *Anti-Lebanon*, on the east of the valley, is longer than that of the Lebanon, though not so generally elevated, and is divided in its southern part by a long narrow defile, known as 'El Bogaz' (the Gorge), through which the high road from Beirut to Damascus, the only carriage road in Syria, passes.

The northern part of Anti-Lebanon has a general elevation of from 5000 to 6000 feet, and one point rises to 6800 feet; the part south of the gorge is a great mountain mass culminating in *Great Hermon*, 9053 feet above the sea, with perpetual snow on its summit.

The slope of the northern part of Anti-Lebanon to the valley is a steep barren declivity, destitute of trees, except in the narrow glens. South from the summit of Mount Hermon is an extensive mountain tract, in great part covered with thick wood, and used as pasture land.

'El Bekaa,' the part of the valley of Cœle Syria watered by the Litany, is famous for its fertility, though but a small part of it is under cultivation. In its lower course, between Mount Hermon and the Lebanon, the valley of the Litany is narrowed, and afterwards becomes a deep chasm with fearful precipices. Reaching the lowest ground, between the Lebanon range and the plateau of Galilee beyond it, the Litany turns due west to the sea. From the plain to its mouth the river has a fall of more than 1200 feet.

There is a second, but minor valley, between the Lebanon and Anti-Lebanon, running parallel to the lower course of the Litany before it turns to the west, which contains the geographical *source of the Jordan*, 1847[1] feet above the sea.

Jordan.

Near the point where the stream from the fountain of Banias, the rival source, joins the Jordan, the valley widens, and the lower part of it is occupied by the Ard El Huleh, a swampy region terminating in the reedy lake of the same name, which is only about 100 feet above the sea. The Jordan falls rapidly from this to the Sea of Tiberias, 636 feet below the Mediterranean. This lake occupies the whole bottom of the valley at this point, so appearing to be surrounded by mountains, and it has a narrow fringe of tropical vegetation round its margin. Its waters are cool and fresh, and the course of the Jordan may be traced through it in a smooth current.

The Jordan now enters the main part of its course in the 'Ghor,' or Jordan valley, which has a general width of about 10 miles, less in the north, and greater in the south next the Dead Sea, bounded on both sides by mountains. The mountains on the east side of the 'Ghor' rise almost perpendicularly from the river course, and have been compared to a huge wall. The higher terraces on each side of this valley, immediately below the mountains, are occupied with masses of vegetation.[1] This is succeeded by the desert plain, or 'arabah,' properly so called, from which begin the regular descents to the river. The Jordan flows in a narrow secondary valley, which has a width of about three quarters of a mile, and is at a lower level than the general base of the 'Ghor,' but covered with trees and luxuriant herbage, forming a long dark line of verdure, winding through the valley.

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[1] Duc de Luines.

The lowest part of the depression of the Ghor is occupied by the Dead Sea, whose surface is 1298[2] feet below the level of the Mediterranean.

The Jordan has then a fall of 1717 feet between its source and Lake Huleh, 736 feet between Lake Huleh and the Sea of Tiberias, in the short distance of 10 miles between these, and only 664 feet in the 70 miles of direct distance between the Sea of Tiberias and the Dead Sea.

Dead Sea.

The deepest part of the Dead Sea is 1308[3] feet below its surface, or 2606 feet (half a mile) below the level of the Mediterranean. This hollow has been called the 'deepest depression on the surface of the earth,' and it is true that no other uncovered land is known to exist at such a depth below the general level of the sea as that which surrounds the Dead Sea; but in the North Atlantic, a depth of seven English miles has been found, indicating a depression of the earth's crust fourteen times as great as that in which the Dead Sea lies.

The temperature of the water of the Dead Sea was found by Lynch to decrease from the surface to a depth of 10 fathoms, where the coldest water was uniformly found, and afterwards to increase below this depth. Thus, with a surface temperature of 76°, ten fathoms gave 59°, and 174 fathoms 62° Fahr.

The greatest length of the Dead Sea is 46 miles, and its average breadth 7 miles. Its surface covers an area of 495 square miles.[4] The north shore of the sea is an extensive marshy flat, with a sandy plain beyond it. A line of bold cliffs of bituminous limestone, rising to a height of from 1000 to 1200 feet, runs along the western side of the sea, broken by a few ravines, leaving a narrow shore. These rocks present a scene of utter desolation, and are devoid of vegetation, except in the narrow clefts. The cliffs continue till within about four miles from the south shore of the sea, where there is the remarkable isolated mountain mass of rock salt called Jebel Usdum (Sodom), and between the northern end of it and the sea, a cylindrical pillar of salt 40 feet in height. Between the base of Jebel Usdum and the sea is an extensive marsh coated with salt and flaky bitumen, intersected by sluggish streams. The eastern side of the sea has a broad uneven shoreland in the south, but rises directly in the northern part to the mountains of Moab, which continue the edge of the East Jordan plateau, and rise to from 2000 to 3000 feet above the Mediterranean, though to a much greater relative height from the Dead Sea. A peninsula called '*El Lisan*' ('the tongue'), extends from the eastern shore, and divides the sea into two unequal basins; it stretches north and west into the sea for about eight miles, has a rugged surface, and terminates to northward in a bold promontory 40 to 60 feet high. The sea to the north of the promontory lies in a deep trough, with a bed sloping rapidly from the shore to as much as 1308 feet in one part, but the southern basin is exceedingly shallow, and is fordable across its centre, the greatest depth found in it being only fifteen feet.

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[1] Stanley's Palestine.

[2] Ordnance Surveyors.

[3] Lynch, U. S. Expedition to the River Jordan and the Dead Sea, 1848.

[4] Vignes and Luynes.

The waters of the Dead Sea contain between 24·5[1] and 26·25[2] per cent. of salts, whilst the mean salinity of the ocean is only about 3·5 per cent.; but the Dead Sea is by no means singular in respect of its saltness, or even the saltest among salt lakes, since other lakes in various parts of the world have been found to have as great, or a greater salinity: thus the waters of the Great Salt Lake of Utah have 23 per cent.[3] of salts in solution; Lake Elton, on the steppes of the Volga, 20 per cent.; and Tuz Gol Lake, in Asia Minor, as much as 32 per cent.

The great valley called the *Wadi El Arabah* continues the central depression to the Gulf of Akaba, a branch of the Red Sea. This valley has a continuous slope up from the Dead Sea to the water-parting of the occasional drainage, which lies nearer the Red Sea at an elevation of 747 feet above it, or 2045 feet above the Dead Sea. The whole length of the central depression, from its beginning at the Lake of Antakie to the head of the Gulf of Akaba, is not less than 500 miles in an almost direct line from north to south. It has been inferred from the geological structure of the mountains lining the Dead Sea valley, and from supposed marks of volcanic agency, that the Ghor had sunk in consequence of some extraordinary convulsion; but Stanley concludes that it is most probable that the whole valley, from the base of Hermon to the Red Sea, was once an arm of the Indian Ocean, which has gradually subsided, leaving the three lakes in its bed, with their connecting river; and according to Tristram, there is no trace of volcanic agency in the valley.

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[1] Dr Marcet. [2] Stanley. [3] Dr Gale.

Plateau East of the Jordan.

South of the Anti-Lebanon the Jordan valley is shut in on the east by the great wall of the mountains of Moab, which rise abruptly from the valley and form the edge of the Great East Jordan plateau, described as a 'wide table-land tossed about in wild confusion of undulating downs, clothed with rich grass throughout; on the southern parts trees are scattered here and there, aged trees covered with lichen, as if the relics of a primeval forest long since cleared away; the northern parts still abound in magnificent woods of sycamore, beech, terebinth, ilex, and enormous fig-trees. These downs are broken by three deep defiles, through which the rivers Yarmûk, Jabbok, and Arnon, fall into the valley of the Jordan. On the east they melt away into the vast red plain which, by a gradual descent, joins the level of the plain of the Hauran and of the Assyrian desert.'[1]

The Knot of *Jebel Hauran* rises out of the level plain far to the east of the Lake of Tiberias. Its highest summit is 6034 feet above the sea. The north and west of this mountain region is wooded and partly cultivated, but the east and south sides are barren, for there the stony desert of Syria begins. Damascus lies in a wide fertile plain between the Anti-Lebanon on the west, and the Syrian desert on the east. In the lowest part of this plain, to the east of Damascus, are several extensive swamps, in which the rivers descending from the Anti-Lebanon lose themselves. The well-watered tract called El Gutha, in the midst of which Damascus stands, is the most productive spot in Syria. The town is surrounded with garden and orchards, yielding all the fruits of Southern Europe. Corn-fields extend to a great distance, inclosing this forest of fruit-trees.

The western barrier of the Jordan valley is a continuous plateau, with an average breadth of 25 to 30 miles, stretching from the

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[1] Stanley's Palestine.

Plateau West of the Jordan.

base of the Lebanon southwards to the desert of Arabia, separated from the sea by the long green fringe of the maritime plain, and only broken into by the rich plain of Esdraelon. The water-parting of the plateau is near the edge of the slope into the Jordan valley throughout, and from this the streams flow east to the Ghor, and west to the sea. The streams from the south of the parallel of the Sea of Tiberias to the Nile Delta are, with the exception of the River Jordan, periodical torrents, dried up in summer by the fierce heat of the sun. To the north of this area the rivers and streams are constant. The periodical streams or dry river beds are termed *wadi;* the constant streams, *nahr*, in the north of Syria.

The part of this plateau to the west of the Sea of Tiberias, and north of the plain of Esdraelon, has been called the *Plateau of Galilee*. This region of mountain and forest rises highest to the north-west of the lake, where some points are more than 3500 feet in height. On the north the highland reaches the sea, and breaks off in the bluff promontories of the '*Tyrian Ladders*,' 260 feet in height, without leaving any sea beach; but to the south the wide plain of Akka, or Acre, which forms the embouchure of the plain of Esdraelon, separates the base of the plateau from the coast.

Mount Tabor, 1890 feet, an isolated, round, flat-topped hill, the highest in Southern Galilee, by some writers supposed to be the scene of the transfiguration; and a fertile range to the south-west of it, 1700 feet in height, is the Hermon of the book of Psalms, called *Little Hermon*, to distinguish it from the lofty summit of the Anti-Lebanon. Due west of Mount Tabor, and separated from the Galilean plateau by the plain of Esdraelon, is the long ridge of *Mount Carmel*, an extension of the main part of the West Jordan plateau. It terminates in the most marked promontory of the Syrian coast, in a height of about 600 feet, with a broad beach round its base. The highest point of the ridge is 1740 feet above the sea, its summits are covered with forest, and its slopes with the richest pasture.

The *Mountains of Samaria* form the central mass of the hills of Palestine, at an average elevation of half-a-mile (2000 to 3000 feet) above the sea, broken up into wide plains with continuous tracts of verdure, and beautifully wooded. The huge rounded mountains of Ebal and Gerizim, 3160 and 2980 feet high, are the most elevated part of the mass. They are separated by a narrow valley only 200 to 300 paces in breadth, and are memorable as the scene of the delivery of the blessings and curses of the Law.

The *hill country of Judæa*, to the south of the plateau of Samaria, is more barren in the parallel of Jerusalem than to south or north of it, more divided by valleys and torrents, becoming a highland down with precipitous ravines on the side next the Dead Sea. It rises highest in the district round Hebron, which is 3029 feet above the Mediterranean, or 4327 feet above the Dead Sea, and slopes off from thence to the southward to the Desert of Arabia. Jerusalem stands near the central point of the highland, on an eminence within a basin surrounded by heights, embraced by the double-head valleys of a wadi, which seeks the Dead Sea. From every side but the south the ascent to Jerusalem is perpetual. Its height above the Mediterranean is 2550 feet, or 3848 feet above the Dead Sea.

Maritime Plains.

The central plateau of Palestine terminates on the west in the maritime plain of Philistia, called '*Sephelah*,' or the *lowland*. This plain is divided into two parallel belts; a sandy tract next the shore, and a cultivated tract farther inland, at the base of the mountains, with slight eminences, wide corn fields, gardens, and orchards. The town of Yafa, or Joppa, on the coast of the plain, is surrounded with orchards of oranges and other fruits. On the south, Sephelah merges gradually into the great pastures, and these into the Arabian desert; on the north it unites with the less level and less fertile *plain of Sharon*, which, like the Philistian plain, is separated into a sandy and a fertile tract, the latter called 'Khassab,' or the Reedy, from the number of reeds which grow on the banks of some of the streams flowing through it to the Mediterranean. It is interspersed with corn fields and trees, the remnants apparently of a great forest which existed here down to the second century.[1]

The broad beach round the base of Carmel leads into *plain of Akka*. This is the outer part of the great uneven *plain of Esdraelon*, which runs from this for 20 miles eastward to the edge of the valley of the Jordan, separating the hills of Galilee from those of Samaria, and presenting in spring time the appearance of a vast waving corn field. The cliffs of the Tyrian Ladders, reaching down to the sea, break the maritime plain; but the narrow shore land to the north of them presents the same features of a sandy coastland, and a fertile belt at the base of the mountains.

The land enclosing the Levant on the south presents a great contrast to that which bounds it on the north, being low and flat on

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[1] Stanley.

South Coasts of the Levant.

the coast, and to a great distance inland. The contour line, of one-sixteenth of a mile (330 feet), shows that there is a great area below this height on this side of the Levant, the lowland extending from sea to sea in the Isthmus of Suez, and far inland into Africa, in the delta and valley of the Nile. The country which separates Palestine from Egypt is the desert region of Arabia Patræa. The Mediterranean coasts of this region are low and flat, continuing the maritime plain of Palestine, which gradually changes its character from a pasture land to the scorched sandy desert of the southern shore of the sea; but the height of the desert increases to the southward, where two outer elevated regions run parallel to the Gulfs of Suez and Akaba, and unite to form the lofty group of the mountains of Sinai. The wadis of the interior of this region join to reach the sea by the one outlet of the Wadi El Arish, which forms the boundary between Lower Egypt and Syria.

Delta of the Nile.

The *Delta of the Nile* is the wide low plain at the mouth of the river,[1] in the form of a triangle or the Greek letter Δ, from which it was anciently named. It occupies an area of about 9000 square miles, or nearly equal to the third part of the extent of Scotland or Ireland. At the head of the delta the River Nile, which for the previous 1700 miles of its course has flowed through the deserts of North Africa in one course, without receiving a single tributary, divides into two main branches, named from the towns of Rosetta and Damietta, which stand near their mouths. Besides these main channels the whole plain is intersected by artificial and natural canals. There are three great salt marshes on the coast of the Delta, one on each side of the main branches, and one between these, each communicating with the sea by several outlets.

The most remarkable circumstance connected with the Delta of the Nile, is the annual rise and overflow of the river, which takes place with the greatest regularity in time, and equality in amount, and is caused by the periodical rains in the interior of Africa. The river begins to rise towards the end of June, continues to increase till September, then remains stationary for a few days, and again subsides before the end of November. During the inundation the whole Delta is converted into an immense marsh, interspersed with islands. After the subsidence of the waters, the fields are found to be covered with a layer of rich brown slime. The country is then put under culture, and during the winter months presents the appearance of a delightful garden. After the harvest the soil becomes again parched and dusty, and in the end of April the 'Khamsin' (hot wind), begins to blow at intervals from the desert, sweeping along the sand with it, till the rising of the river again refreshes the land. This annual deposition of mud would cause a very gradual raising of the surface of the Delta; but the accumulation is so very slow, that the rise since the time of Ptolemy has been calculated at less than six feet at Cairo, whilst at the mouths of the river the amount of rise is almost imperceptible; but the increase here is probably counterbalanced by a gradual subsidence of the coast land. Though originally formed by the debris worn down and pushed forward by the river into the sea, the Delta does not now increase in extent seawards, since the mud brought to the mouths of the river is carried off to the eastward by the prevailing current of the Mediterranean.

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[1] For the whole Delta of the Nile, *see* Map 18. Mediterranean.

Isthmus of Suez.

Advantage has been taken of the natural lowland between the largest of the salt marshes in the east of the Delta, and the branch of the Red Sea which stretches northwestwards to Suez, to cut a canal to unite the Mediterranean and the Red Seas, to allow the passage of large ships, and thereby greatly to facilitate commerce between the western world and the eastern. This scheme is an old one; but was long laid aside on account of a supposed difference of level between the two seas, which difference has been proved not to exist, or, at most, to be so slight as not to affect the project. The average level of the Mediterranean is half a foot above the Red Sea, but the highest tides in the Red Sea rise four feet above the highest in the Mediterranean, and its lowest ebbs fall nearly three feet below the lowest in the Mediterranean. The canal through the Isthmus of Suez is nearly 100 English miles in length, has a depth throughout of 26 feet, a general width of from 200 to 300 feet at the top of the banks, and of 72 feet at the bottom throughout. Vessels are able to steam or be towed through the canal in sixteen hours from sea to sea, and this effects a saving of half the time employed in the conveyance of goods by the Cape of Good Hope to India. The canal runs for 29 miles through the shallow Lake Menzaleh, through two smaller lakes, and then through a fourth, formed in the depression in which were the ancient bitter lakes, which were below the level of the sea, by the water let into it through the canal from the Mediterranean. The parts between these lakes are cut through low sand hills or plains, slightly elevated above the sea level. The Libyan Desert bounds the Delta on the west; between the Delta and the Gulf of Suez the general character of the country is that of a rocky and mountainous region, intersected by numerous fertile wadis. The highest summit in this region is that of the mountain knot of Jebel Attaka, near the head of the Gulf of Suez, 2610 feet above the sea.

Depths of the Levant.

The depth contours of the eastern part of the Mediterranean present a good example of the fact, that steep coasts have generally a rapidly falling sea-bed next to them, and that, on the contrary, a sea margin sloping gently inland has a corresponding slowly sinking sea-bed beyond it, as if the sea-bed were the form out of which the land had been moulded.

Thus the whole of the high coast of Syria, from the Gulf of Iskanderun to Cape Carmel, has a steeply descending sea-bed from it. In the Sephelah lowland, the contour of one-sixteenth of a mile in height, is almost at an equal distance from the coast, with the depth contour of the same amount; and in the south of the Levant, the plain of the Nile Delta is continued far into the bed of the sea. In the north the sea-bed slopes rapidly below the lofty Taurus, and gently outside of the plain of Tchukur; then it seems to form a great submarine peninsula to embrace the island of Cyprus as a part of the mainland.

Cyprus.

A long horn-like projection from the north-east corner of Cyprus seems to correspond to the hollow of the Gulf of Iskanderun, and the Bay of Famagusta, to fit into the angle of the coast to the south of the gulf, giving the island the appearance of having been pushed by some huge force from this corner, adrift into the Mediterranean. The mountain ridge which forms this peninsula, continues along the whole north side of the island, and a double valley separates it from the central mass of the island to the south, which is capped by the ancient Mount Olympus, 6590 feet above the sea. This mountain mass has bold rugged slopes, thickly wooded and diversified by precipitous cliffs of limestone and deep picturesque valleys.

Palestine and Britain.

The Map of Syria and the Hypsometrical one of the British Isles given in this Atlas, have been drawn on exactly the same scale, so that an accurate comparison of areas and distances may be made between the two countries. Thus the whole territory of Palestine from Dan, near the head waters of the Jordan in the north, to Beersheba, in the parallel of the south of the Dead Sea, is scarcely larger than the little principality of Wales. The course of the Jordan is not so long as that of the Thames or Severn; the Lebanon is a far shorter, though vastly higher range than the pennine chain of England, or the Grampian mountains of Scotland; the Sea of Tiberias covers only about half the area of Lough Neagh, in Ireland, or double the area of Loch Lomond, in Scotland; whilst the Dead Sea extends over an area of only three times that of Lough Neagh. The length of the Suez Canal may be compared with that of the Caledonian Canal, in Scotland, or to the distance from London to Bath, or between Chester and Gloucester.

Climate.

The area embraced in the Map lies outside the border of the mathematical tropic, but in summer is included within the hottest region of the globe. In winter it enjoys a mild climate, being within the zone of winter rains, when the thermometer falls occasionally as low as the freezing point in Jerusalem, and snow sometimes occurs.

The Taurus region, on the north of the Levant, has a mean temperature of 40°, or the same as that of the British Isles in the same month; in the latitude of Cyprus the temperature rises to an average of 50° in January; and in a line from Jerusalem to Cairo the temperature is 55°, or the same as that of Southern Spain or Northern Mexico, in January. In July, the whole region to the west of the Jordan valley, and north of the Arabian Desert, has an average temperature of between 80° and 90°; but in the desert east and south of this line, which marks the boundary of the then hottest region of the earth's surface, extending over Central Africa and the Arabian Desert, the temperature rapidly increases. At Damascus the average July temperature is 95°, whilst that of Jerusalem is only 83°, and of Cairo 86° Fahr.[1]

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[1] The isotherms have been worked out specially for this Map, from observations returned from Alexandria, Cairo, Jerusalem, Beirut, Damascus, Famagusta, and Aleppo, for a considerable number of years, taken in connection with many other stations in the Mediterranean basin. The elevations given by Van de Velde, in the Memoir to accompany his Map of the Holy Land, are the chief basis of the contour lines in Palestine, though all other available authorities have been ransacked for heights. The beautiful map of the Lebanon, in Stieler's Hand Atlas, which is rich in heights, has been used for that region; whilst Kiepert's maps of Asia Minor, with the heights observed by Tchiatcheff and others, complete the lines on the north. The depths are worked out from the Admiralty charts.

GEOLOGICAL MAP OF THE BRITISH ISLES.

MAP 14.

IN the maps which have preceded this one in the Atlas, we have examined the present distribution of land and water on the surface of our earth, and the outward uneven forms of the continents as we find them at the present day, apparently rigid and enduring, the motionless covering of an inert mass which is whirled round the sun, but has no power of change in itself; but examining more closely into its structure and history, we begin to discover that far from this being the case, our globe is a highly organized, almost living body, constantly, though slowly changing its external form in every part. In what is called the solid land, we find a gradual but unceasing process of change. The rain descends upon the sloping land, and forms into rills and brooks and rivers, which deepen the valleys, and carry mud, and silt, and sand, to the sea, gradually levelling the highlands with the coasts. The sea itself beats against the land and wears away the shores, distributing their ruins by its currents throughout the ocean; and frost and ice act powerfully in bursting open the solid rocks, and in transporting their fragments in glaciers to the lower land, or by icebergs, which deposit them in the sea. This constant and sure, if slow process of levelling, if not counteracted by any renewing force, would limit the existence of the land of the globe, and would foretell a time when the whole of the land would be subdued by the devouring sea, which would then roll unbroken round the world; but the researches of geologists open up the history of the past ages of the globe's existence, and show a process of renovation to counteract this process of decay.

In examining the crust of the earth, geologists find that it has not all been formed at one time, but that it consists of a series of layers of solid material, not differing much in their mineral character, but some containing buried remains of strange plants and animals, which must at one time have existed on the open surface. Other strata now forming part of the solid land, have marks of marine animals, proving that these rocks have been formed after the sea was tenanted by its proper forms of life, at the bottom of its bed; so it has been concluded that the process of change in the surface of the land, which we see going on actively around us, has been in motion for countless ages, that the land now exposed has at one time formed the bed of the sea, and that whilst there is a constant wearing down and deposition on one part of the earth's crust, there is as constant an upheaving and restoring process at work in another, which has its origin in the expanding power of the fires which fill the interior of the globe, and evince themselves in the flames of volcanoes, and by shocks of earthquake. We shall afterwards see[1] that evidences of this slow process of upheaval have been noticed within historical times, over considerable areas of the land.

Circulation of the Materials of the Earth's Crust.

Rocks formed by Fire or by Water.

The crystalline formation of many of the rocks which form the outer crust of the earth, requires that the particles composing these rocks should have been, at the time of formation, free or fluid, and this condition must either have been due to the melting power of fire, or to the dissolving power of water. Those rocks which have been consolidated by fusion by fire are termed *igneous;* those formed by deposition in water, *aqueous* rocks. The aqueous are all those layers which have been consolidated at the bottom of the sea, formed by deposits derived from the abrasion of the exposed land: igneous rocks are all those which have been erupted through the earth's crust by the power of subterranean heat. From the nature of their formation by deposition in layers, the aqueous rocks are generally stratified. The igneous rocks, on the other hand, appear as great shapeless masses, or as long dykes, filling the cracks which have been formed in the earth's crust during their eruption. *Metamorphic* rocks form a class between the aqueous and igneous, and are those which have undergone a change in their character, through the action of fire or water or pressure, or a combination of these agents.

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[1] Maps 25 and 26.

Geology of the British Isles.

The British Isles contain perhaps the most complete model representation of the structure of the earth of any similar area on its surface. The Map of these islands in the Atlas is intended to show only the geographical distribution of the rocks in the three great periods into which geologists have divided the aqueous formations, and that of the igneous rocks as a whole, without entering into the divisions of these periods, excepting to show the position of the coal beds in the oldest of them.[1] The brown colour on the map, then, represents the area of the primary or oldest rocks, the yellow that of the secondary, and the green that of the tertiary or most recently formed rocks, sands, clay and alluvium; whilst the places where igneous masses appear on the surface, are coloured in red. In Great Britain, the highlands of Scotland and of western England, are entirely formed of the primary or oldest rocks, with igneous masses protruding between; the central plateau and south-eastern part of England is chiefly of the secondary period, and the flat lands and valleys of the eastern and southern coasts, are of the tertiary or recent formation. The plains of Ireland, on the contrary, lie on the rocks of the primary period, but several of the mountain masses are formed of igneous rock.

In Scotland, the great masses of the northern and central highlands are composed of gneiss, and the southern Highlands of silurian rocks. The Hebrides and the north-western coasts, between Cape Wrath and the Isle of Skye, are of the Cambrian and Laurentian formation, the *oldest* rocks of Britain. Old red sandstone and carboniferous limestone appear most in the lowlands, between the southern and central highlands.

The Pennine chain of England is chiefly formed of carboniferous limestone, and the Cambrian Mountains in Wales of silurian and old red sandstone rocks; the Cornish heights are of old red sandstone and carboniferous limestone. The interior of the plain of York, the central plateau, and the plain of Cheshire, are chiefly of new red sandstone; a broad band of oolite and lias stretches in a curve from the south coast at Portland Bill to the north-east coast near the mouth of the Tees. Detached portions of the chalk formation appear on the outer part of the plain of York, forming the cliffs at Flamborough Head and the wolds of Lincoln, but the great development of this formation is in the south-east of England, marked off by a line joining the eastern side of the Wash with the coast near Portland Bill on the south, where the chalk appears over the whole of the eastern plain and in the plateau between the North and South Downs, breaking off on the coast in the cliffs of Dover, Beachy Head, and the Isle of Wight. The valley of the Thames, and the lowland round Southampton, are almost entirely of eocene; the Fen district and the lowland of the Humber are of alluvium, the most *recently* formed part of the British Isles. The great central plains of Ireland lie chiefly on the carboniferous limestone; the gneiss formation continuing that of the central highlands of Scotland, appears in the north-west; and the mountains of the south-west are of old red sandstone.

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[1] These main divisions have been drawn on the small Map in the Atlas from a recent one by Mr Geikie, the director of the Geological Survey of Scotland, who is also the authority for the table of the aqueous rocks which is given below.

Granite protrudes in scattered masses through the highlands of Scotland, and trap rocks between the valleys of the Tay, Forth, and Clyde, whilst numerous long dikes of trap cross the southern highlands and the north of England. The greatest masses of granite appear in Dartmoor and at Land's End in England, and in Ireland granite forms the greater part of the Wicklow, Mourne, and Donegal Mountains, and a large area of it crops up in the south of Galway. In the north, a great area of trap rock forms the basin of the River Bann, and surrounds Lough Neagh.

The table on the opposite page shows the order in which the different aqueous rocks have been deposited in the three periods of time one above another.

Objects of the Study of Geology.

The higher objects of the study of geology, in tracing the history of our earth, and of the successive races of plants and animals which have inhabited it before it was fitted for the dwelling of man, have been previously indicated. The science has also practical uses, not only in pointing out the locality and extent of the formations of rocks and metals and minerals which are useful and necessary to man, but also in the whole human economy, since the nature of the geological formation of a country, determines to a great extent its fertility or barrenness, and affects its climate, as also its healthfulness or the reverse, since some diseases prevail over certain geological formations which are absent in others.

POST TERTIARY PERIOD.	RECENT.		Modern alluvium, peat & raised beaches.
	POST PLIOCENE.		Ancient alluvia of the Thames, Ouse, etc.
			Cave deposits.
			Glacial drift.
TERTIARY OR CAINOZOIC PERIOD.	PLIOCENE.	Newer.	Norwich Crag.
		Older.	Red Crag.
			Coralline Crag.
	MIOCENE.		Leaf beds of Mull, basalt of Antrim.
			Lignite of Bovey Tracey.
	EOCENE.	Upper.	Upper part of fluvio marine beds of Isle of Wight.
		Middle.	Lower part of fluvio-marine beds of Isle of Wight.
		Lower.	London Clay.
			Woolwich and Reading beds.
			Thanet sands.
SECONDARY OR MEZOZOIC PERIOD.	CRETACEOUS.	Upper.	Chalk.
			Upper Greensand and Gault.
		Lower.	Lower Greensand.
	WEALDEN AND PURBECK.		Weald clay and Hastings sand.
			Purbeck beds.
	OOLITIC OR JURASSIC.	Upper Oolite.	Portland beds.
			Kimmeridge clay.
		Middle Oolite.	Coral rag, or coralline oolite.
			Oxford clay.
			Cornbrash and Forest marble group.
		Lower Oolite.	Great or Bath oolite.
			Fuller's earth.
			Inferior oolite.
		Lias.	Sands, upper lias clay.
			Marlstone
			Lower Lias clay.
	NEW RED SANDSTONE OR TRIASSIC.	Keuper.	Penarth or Rhætic beds.
			Red marls, with rock salt and gypsum.
			White and brown sandstones.
		Bunter.	Upper red and mottled sandstones.
			Pebble beds.
			Lower red and mottled sandstones
PRIMARY OR PALÆOZOIC PERIOD.	PERMIAN.		Magnesian limestone.
			Conglomerate, sandstone, and red marl.
	CARBONIFEROUS.		Coal measures.
			Millstone grit.
			Upper limestone, shale, and carboniferous limestone.
			Lower limestone shale; calciferous sandstones of Scotland.
	OLD RED SANDSTONE OR DEVONIAN.		Upper.
			Middle.
			Lower.
	SILURIAN.	Upper.	Ludlow beds.
			Wenlock beds.
			Upper Llandovery rocks.
			Lower Llandovery rocks.
		Lower.	Caradoc or Bala beds.
			Llandeilo flags.
			Lingula flags.
	CAMBRIAN.		Cambrian sandstones, grits, shales, and conglomerates.
			Fundamental or Laurentian Gneiss.

Hydrography.

OCEAN CURRENTS AND RIVER SYSTEMS.

Maps 15 and 16.

'The ocean has its system of circulation so ordered, that its waters, whether at the surface, or in the depths below, are seldom or never at rest; and this circulation is all pervading and perpetual, as constant in the horizontal as it is in the vertical direction.'—Maury.

Causes of Currents.

This circulation is caused by the revolution of the earth round its axis, and by the power of the sun's heat acting through various secondary influences, such as difference of temperature and consequent difference of density, evaporation and rain bringing about a difference in salinity or weight, and winds, all traceable to this one great cause. The rotation of the earth from west to east causes an apparent westerly flow at the equatorial regions, where this motion is greatest, the inertia of the waters tending to leave them behind; again, the sun's heat acting on those parts of the ocean which pass most directly under it, causes rapid evaporation, and the water thus carried up into the atmosphere, must be constantly replaced from below; and this heat, by diminishing the density of the water, expands its bulk, so causing it to overflow on each side of the Equator towards the Poles. Thus, from these two causes, we have at once established an east to west motion of the waters at the Equator, and a double flow from the Equator towards the Poles, the obstructions to these movements by the intervening land giving rise to local currents.

These currents of the ocean must be distinguished by the significant names of *stream* and *drift*. The *drift* current is merely the effect of the prevailing wind on the surface of the water: but the *stream* current is a powerful river, forcing its way through the ocean, maintaining a uniform direction, and little affected by temporary adverse winds; but again the *drift* current, caused by a constant wind, may, on meeting a coast, become a *stream* current; or a *stream* current, on losing its original impetus, may be carried on as a *drift* current by a prevailing wind. The constant winds of the globe, the trade winds, have a great share in aiding the motion of the currents, and nowhere do we find a constant wind blowing directly against a constant current, but on the contrary, each mutually aiding the other, both having the same original cause of motion.

Currents of the ATLANTIC OCEAN.

Gulf Stream.

The surface currents of the Atlantic Ocean have been best described; most of them may be considered as parts of a great current which takes its apparent rise in the Antarctic region, and travels through the ocean, keeping along the west coast of Africa and the north of South America, to the Caribbean Sea, then passing round the Gulf of Mexico, and out into the open ocean, flowing towards Europe. The different parts of its course have various names. This current first has its name of *Gulf Stream*, when it reaches the Gulf of Mexico from the Caribbean Sea. It passes completely round this gulf, and rushes out into the Atlantic with its greatest force, between Florida and the West India Islands, at the point known as the 'Narrows.' This best known of the ocean streams has been also considered as the greatest of them, but is in reality only one among the great currents, and is surpassed in volume, and perhaps also in average rate of motion, by at least two others hereafter described. Turning first abruptly north, and afterwards north-east with gradually diminishing force, it continues quite across the Atlantic, in the latitude of Central Europe. Part of its waters, drifted on by the prevailing south-west winds, maintain the north-easterly direction, in what is termed the *Gulf Stream Drift*, between the British Isles and Iceland, and thence to the Norwegian and North European, and perhaps Asiatic coasts of the Arctic Ocean. A minor branch of the current sets along the north coast of Spain, round the Bay of Biscay, along the French coast towards the south of Ireland, where it rejoins the north-easterly drift. This branch, known as *Rennel's Current*, has a greater rate of motion than the general current, which increases to 24 miles a day on the north coast of Spain; but by far the greater part of the water set in motion by the Gulf Stream recurves in the North Atlantic, between the Azores Islands and the coasts of Europe and North Africa to the south-east and southward, and then, aided by the north-east trade wind, passes back again to the west in a wide *drift*, occupying the greater part of the ocean, and known as the *North Equatorial Current*, to rejoin the original stream at various parts of its course.

The water of the Gulf Stream is of a deep indigo blue colour, and its junction with the ordinary sea water is distinctly marked. At the surface, near the coasts of the United States, it is divided into bands of higher and lower temperature, of which the axis of the stream or line of greatest velocity is the hottest, and these features are observed to a considerable depth. Between the stream and the water of the cold current, afterwards noticed, next the coast, the fall of temperature is so sudden, and the line of separation so marked, that it has received the name of the 'cold wall,' and a difference of 30° Fahr. has been observed within a few ship's lengths in crossing it.[1] The limits of the warm water are variable, since north-east and south-east gales force it towards the American shores, whilst north-west and west gales drive it from them. The stream is also considered to be more north and south in correspondence with the sun's declination, attaining its extreme northern limit in September, and its southern in March: the volume of the stream is probably diminished at the latter season. The warm water of the Gulf Stream never reaches the sea-bed, but flows over water which has a lower temperature. In the 'Narrows' the probable depth of the warm water is perhaps only a third of that of the depth of the straits, or from 100 to 150 fathoms; and throughout its course in the Atlantic, the warmer water perhaps never reaches a greater depth than this; more probably its depth diminishes rapidly in spreading out to cover a larger space.

The velocity of the Gulf Stream varies with the season, and it runs with its greatest strength when the sun is north of or returning to the equator. On entering Florida Strait from the Gulf of Mexico, its rate is from 60 to 100 miles per day; on leaving the 'Narrows' 70 to 120 miles.[2] Beyond this the rate gradually decreases to 24 miles a day off the south coasts of Newfoundland. When the drift recurves to the southward at the Azores, the rate is not over 7 miles per day on an average; but after passing into the region of the north-east trade winds, it is increased to 10 and 12 miles. The *Gulf Stream Drift*, between the British Isles and Iceland, moves very slowly, the observed rate being only 5 miles a day near the British side, and 3 miles on the Icelandic side of the channel,[1] decreasing to the northward to the insignificant amount of 1 mile per day. On issuing from the Gulf of Mexico, the Stream has a maximum temperature of 85° Fahr., or 5° to 6° above the mean ocean temperature in that latitude, and off the banks of Newfoundland is higher by 20° to 30° than the adjoining ocean. The following table gives the average temperature of the axis of the stream, or warmest band of water:—

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[1] Board of Trade Meteorological Returns. [2] Bache, U.S. Coast Survey.

	Latitude.	*Winter.*	*Spring.*	*Summer.*	*Autumn.*
Florida Strait, . . .	25° N.	77°	78°	83°	82°
Off Charleston, . . .	33° N.	75°	77°	82°	81°
Off Cape Hatteras, . .	35° N.	72°	73°	80°	76°
South-east of Nantucket Shoals,	35° N.	67°	68°	80°	72°
South of Nova Scotia, . .	35° N.	62°	67°	78°	69°

South Atlantic Current.

The *South Atlantic Current* is a branch of the great cold Antarctic drift, which divides off the south of Africa, at the point where it turns back the warm Agulhas Current from the Indian Ocean. This branch is joined by a small portion of the warm water of the Agulhas Current, which escapes round the coast of the Cape, and aided by the south-east trade wind, sets up along the West African coast to the equator, where it merges into the *South Equatorial Current.* Its general rate is about 18 miles a day off the Agulhas Current, 24 miles on the coast of Africa, and again 18 miles as it nears the equator. Its temperature off the Cape of Good Hope is perhaps 50° Fahr. on an average; and the sudden difference between its waters and those of the Agulhas Current, has been repeatedly observed to be more than 20°; it gets warmer as it advances northwards, till, on becoming the South Equatorial Current, it has a temperature upwards of 70° Fahr.

South Equatorial Current.

The *South Equatorial Current* passes from this westwardly across the Atlantic, occupying a breadth of nearly 10° of latitude, the greater part to the south of the equator, with a rate varying from 18 to 24 miles a day, till it reaches the South American coast. Off Cape St Roque it divides into two. One branch passes south-westwards along the Brazilian coast, but the greater part maintains a west and north-west direction along the north coast of South America to the

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[1] Irminger, in Maury's Sailing Directions.

Caribbean Sea, afterwards to form the Gulf Stream. The *Brazil Current* has an average rate of 24 miles a day, at the point where it leaves the Equatorial Current, and gradually diminishes in strength as it proceeds to the southward, recurving to the eastward off the mouth of the Rio de la Plata, where the currents are variable. Within the South Atlantic, Equatorial, and Brazil currents, and the Antarctic drift, there seems to be a complete surface circulation of the waters induced by these currents and the south-east trade wind which moves the water before it at the rate of about 12 miles per day. The southern part of this circulation is sometimes called the *South Atlantic connecting Current.*

The surface temperature of the *South Equatorial* current is, for a great part of the year, several degrees colder than the adjacent *Guinea Current*, since its waters come from the Antarctic region. It attains its greatest volume and velocity during the summer of the Northern Hemisphere, from the African coast almost to the 15th degree of west longitude. The maximum strength has been observed in June and July.[1] The northern well marked line of separation between it and the *Guinea Current* has been traced in the space extending from the meridian of Greenwich to 23° W., and is found to vary very little at the several seasons of the year. Between 5° E. and 15° W. the mean surface temperatures of the Equatorial Current are from December to March 78° to 82°, March to July 82° to 72°, July to October 72° to 75°, October to December 75° to 78° Fahr.

Guinea Current.

Between the North and South Equatorial Currents of the Atlantic flowing west, a stream current is observed running to the eastward, and along the African coast to the Gulf of Guinea, extending southwards to the 2d and 3d parallels of N. latitude. Its western limit can be traced at all seasons of the year as far as the 23d meridian of west longitude: but in the summer and autumn months especially, an extension of this current to the westward beyond this as far as the 53d meridian, and running from 15 to 30 miles a day, is frequently felt. This current appears to be a resuction of the waters to the eastward, to partly counterbalance the great masses moving to the west on each side of it, and its area corresponds to the region of calms and rains between the trade winds. It is joined on the African coast by a minor branch of the return current of the Gulf Stream known as the *North African Current.* The space separating the

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[1] Board of Trade Meteorological Returns.

Guinea Current from the *South Equatorial* is generally limited, thus presenting the curious feature of two well marked streams running in exactly opposite directions side by side. The *Guinea Current* may be considered as a warmer current than the *South Equatorial* at all seasons.[1] Its average velocity is 30 miles a day off the coast of Africa, decreasing to 10 miles as it runs eastwards, and its remaining strength probably turns to aid the South Equatorial Current on reaching the African coast.

Currents of the ARCTIC OCEAN.

The surface waters of the *Arctic Ocean* seem to have a circular movement, passing round the Asiatic side of the sea from the Atlantic, in continuation of the so-called *Gulf Stream Drift*, and returning on the North American side, in the cold currents of East Greenland and Baffin Bay. The current from Behring Strait is found setting to the north in spring and summer, and thence along the north-east coast of Asia to the westward as far as 140° E.;[2] in autumn and winter this order is reversed. These currents thus counteract one another, and the strait at best is so narrow and shallow, as to play a very insignificant part in the circulation of the water between the two great oceans.

East Greenland Current.

The cold current which moves down the east coast of Greenland from the sea to the west of Spitzbergen, carries with it a constant stream of ice; arrived at Cape Farewell, with an average rate of perhaps 10 miles a day, it turns to the west and north-west into Davis Strait, and along the west coast of Greenland to perhaps 64° or 65° N. This current probably varies in direction at different seasons of the year; and some observations would show that it passed up the whole west coast of Greenland, only returning to the southward at the head of Baffin Bay. Arctic explorers have found strong currents and tides flowing out of the various channels between the islands of the Arctic archipelago towards Baffin Bay and Davis Strait, and these uniting, form the ice-bearing current of the east coasts of North America, known as the *Davis Strait*, or *Labrador Current*. This great cold current, charged with icebergs and field ice in spring, meets the Gulf Stream off the banks of Newfoundland, and passes partly under it, as is proved by its carrying icebergs quite across the course of the warm current to 36° N. latitude, and partly down the American shores,

Labrador Current.

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[1] Board of Trade Meteorological Returns.

[2] Wrangell's Polar Seas.

holding the Gulf Stream away from them, forming the 'cold wall,' and passing finally under it near Florida, to re-appear as a south-easterly current on the north sides of the West Indian Islands. A large part of this current is also deflected by the Gulf Stream into its course to the north-eastward, to aid the 'Gulf Stream Drift,' probably contributing as much to its volume as the Gulf Stream does. The average rate of the *Labrador Current* is 10 miles a day off the Labrador coasts, 12 miles off Newfoundland, and 10 to 13 miles on the coasts of the United States. The part of this current which turns with the Gulf Stream to the east, has a rate of from 8 to 10 miles, whilst the warmer water flows at not much over 6 miles a day on an average.

Currents of the INDIAN OCEAN.

The surface currents of the monsoon region of the North Indian Ocean, to as far as the 10th parallel of south latitude, are periodical drifts, taking their motion from the winds; but the currents of the southern region of the ocean, are as constant as those of the Atlantic. The motion of the water is here again a circular one, taking a direction from South-Western Australia, by Madagascar to South Africa, and thence back to Australia. Aided by the constant south-east trade wind, a mass of water moves across the South Indian Ocean known as the *South Equatorial Current*, between the parallels of 10° and 20° S. towards the African coast, and passes partly to the south, and partly to the north, of Madagascar. Hemmed in by the land, the water pressed against it escapes to the south between Madagascar and the mainland of Africa in the strong *Mozambique current*, which rushes down the south-east coast, past Natal, and the Cape Colony, taking its name now from Cape Agulhas. Arrived at the western side of the Agulhas Bank, the main part of the current is deflected by the action of the heavy Antarctic Polar current; first to the southward, then south-east and eastward, recurving into the Indian Ocean, and setting along the 40th parallel towards Australia, with diminished strength. The warm waters of the *Agulhas Current* reach farthest west in the months of January and February, when the north-east monsoon blows in the upper part of the Indian Ocean, and its stream is weakest in July and August during the south-west monsoon, since a large part of the water brought to the African coasts by the *South Equatorial Current* is then turned into a northerly current flowing towards India and the Arabian Sea. Surface-water at a temperature of 70° Fahr. reaches to 15° E. longitude, and between

Agulhas Current.

35° and 40° S. latitude, off South Africa, in January and February, and only to between 30° and 35° E. longitude, and 25° to 30° S. latitude, in July and August.[1] A small branch of the *South Equatorial Current* seems to bend round the south and west coasts of Madagascar in the Mozambique Channel, afterwards turning into the southerly current.

The average rate of the South Equatorial Current is 14 miles a day; of the Mozambique Current, 24 miles in the north part of the channel, and as much as perhaps 80 miles off Cape Corrientes on the Tropic of Capricorn (where it has been observed rushing along with a velocity of 140 miles a day),[2] or quite as strongly as, and with greater volume than the Gulf Stream at its greatest, decreasing to an average of 50 miles a-day off Cape Colony, and in its bend to the south and eastwards. In its course towards Australia the *retrograde current* has an average rate of 24 miles a day, and is aided by a part of the Antarctic drift, which turns eastward with it from the Cape to South Australia. The south-west corner of Australia divides this current: half of it passes northwards along the coast as the *West Australian Current*, again subdividing, partly to form the beginning of the *South Equatorial Current*, and partly to continue round the Australian coast to the north-east; and half moves on in its easterly direction with the Antarctic drift to form the *South Australian Current*, gradually diminishing in rate from 14 miles a-day as it turns south, outside of Tasmania. Off the south-west cape of Australia, the temperature of this current varies from 61° to 65°, but on the meridian of Tasmania it is only about 48° Fahr.

North Indian Ocean.

The heated surface waters of the North Indian Ocean are in constant circulation, and find an exit into the Pacific during the south-west monsoon, in the channels of the East India Islands between Asia and Australia, and in the Mozambique and Agulhas Currents to the southward during the north-east monsoon.[3]

When the *north-east monsoon* is blowing, a current, formed by the surface waters driven to the south-west in the China Sea, pours out of the Strait of Malacca between Sumatra and the Malay peninsula, and flows across the Gulf of Bengal. Reaching the east coast of India, the current is turned to the south-westwards; a portion of it passes between Ceylon and the mainland, but the greater part continues southward, round the outside of Ceylon, clinging to its coasts, and turns round them into the Arabian Sea. In this sea there is already a general south-westerly motion of the surface waters before the north-east monsoon, into which the current from the Gulf of Bengal merges. This drift in the Arabian Sea has its greatest strength where the water is pressed by the wind against the south-east coast of Arabia, and on the east coasts of Africa, after which, joining into the Mozambique Current, it causes the increase, and the western extension noticed in the Agulhas Current at this season.

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[1] Dutch Charts of Sea Temperatures, Utrecht. 1861.

[2] Becher, Nautical Magazine.

[3] See Map 22.

During the *south-west monsoon* this order of surface currents is reversed. On the East African coasts, a south-easterly current begins in March and April, and sets into the Arabian Sea. Meeting the coasts of India, the waters are deflected along its western shores to the south eastward, the velocity of the current increasing as it passes south; a part of it escapes between Ceylon and the mainland, and part continues round the south coasts of that island into the Gulf of Bengal. On the east coast of Ceylon a sort of eddy is formed by the current in setting through the strait in this monsoon, and bending south eastward to rejoin the easterly current passing south of the island. The greater part of the surface waters of the Gulf of Bengal has now a motion to the north-east. The pressure against the opposite coasts causes a circular current,[1] at the head of the gulf, which flows first north and then west past the mouths of the Ganges, then southwards to rejoin the north easterly drift. Off the mouths of the Irrawadi the drift is turned to the south-east along the coasts, and escapes partly through the Strait of Malacca, and thus into the China Sea, and partly round the north-west end of the island of Sumatra.

The average rate of the *north-east monsoon current* is, in the Strait of Malacca 30 miles, on the east coast of India 24 miles, on the east coast of Ceylon 40 miles, and on the Arabian coast 18 miles, a day. Before the *south-west monsoon* the drift on the African coast, and in the Arabian Sea, moves to the north-east at the average rate of about 24 miles a day; on the western shores of India, the speed seems to be increased to about 30 miles, and on the south coast of Ceylon to 45 miles a day. Over the Gulf of Bengal and in the Strait of Malacca, the average strength of the drift is 20 to 24 miles.

During the greater part of the year a *counter current* to the south Equatorial, corresponding to the Guinea Current of the Atlantic, flows to the eastward, between the Equator and 4° to 5° S. latitude. It crosses the entire ocean from near Africa to the East Indies, and is variable in its rate, sometimes between March and May, attaining 50 to 70 miles a day.

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[1] Heathcote, R. G. S. Journal. 1862.

Red Sea and Persian Gulf.

The surface temperature of the upper part of the Indian Ocean, surrounded as it is by land, is very high in comparison with that of the other seas in the same latitude, the average being as much as 87° as a maximum in the centre of the Arabian Sea, and generally upwards of 80° Fahr. in the parts of the ocean north of the Equator. The evaporation from the *Red Sea* has been calculated at the enormous amount of 165 cubic miles of of water annually.[1] From this cause, and from its position in the centre of an almost rainless region, it is evident that to supply this loss there must be a constant inflow from the Indian Ocean; but the surface current is dependent on the winds, and flows southward during the north-east and north-west winds, which prevai in the eight months, from the beginning of April to the end of November, the hot season; and northward when the southerly winds blow in the southern parts of the sea, from December till the end of March. It is, however, the special and remarkable distinction of this short cooler season, that during it the level of the sea is reduced, and the coral banks are exposed.[2]

From May to September during the south-west monsoon, a surface current runs into the *Persian Gulf*, and this current is reversed during the north-east monsoon.

Currents of the PACIFIC OCEAN.

The currents of the Pacific have a strong resemblance to those of the Atlantic, the system of circulation in each being almost precisely the same, modified by differences in the form of the enclosing land, though on a grander scale in the greater ocean. All the currents of the Atlantic are constant in direction, and this is also true of those of the Pacific, excepting that part of it which lies in the monsoon region of Eastern Australasia and the China Seas, and a small area on the coast of Central America. The circulation of the water of the North Pacific is most marked in that current which corresponds exactly to the Gulf Stream of the Atlantic, called the *Japan Current*. This current seems to be formed by the union of two others, which flow to the westward on the north and south sides of the Equator, whose waters meeting the East India Islands are deflected by them in great part to the north-west, in the same way as we find the water of the South Equatorial

Japan Current.

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[1] Buist in R. G. S. Journal. 1854.

[2] Schweinfurth in Petermann's Mittheilungen. 1868.

Current of the Atlantic turned to form the Gulf Stream by the north coast of South America. The drift to the northward from the Indian Ocean and the channels of the East Indies, during the south-west and south-east monsoons may also aid considerably to increase the strength of the Japan Current. Bending to the north-east off the island of Formosa, with a width of about 100 miles at its narrowest, this united stream first has the name of the *Japan Current*, thence it flows to north-east along the shores of the islands of Japan as one current, gradually spreading itself, and presenting warmer and colder bands such as are observed in the Gulf Stream, till, in the latitude of the middle of the North Island of Japan it sends off a branch to the north-eastward towards Behring Strait, known as the *Kamtchatka Current*. The main part, aided as the Gulf Stream is by the prevailing westerly winds, holds its course round the North Pacific, as a drift current towards the North American shores. Here it sends off a branch to the south-east along the American coast, as a colder current; but the greater part of it, caught into the north-east trade winds, is carried on by them to south-west and west, recrossing the Pacific as a broad drift, chiefly between 10° and 20° N. latitude. During the southerly monsoon, and perhaps also to a less extent at other seasons, a current flowing to the north-east at an average rate of about 24 miles a day, has been observed on the west side of the Japanese islands. Off the south-west corner of the north island of Japan it divides, and passes partly northward along the west coast, and partly through the channel which separates this island from the middle one, with an average strength of 48 miles a day.[1]

The rate of the Japan Current varies, and is naturally strongest during the south-west and weakest during the north-east monsoon. Off Formosa its average motion may be 10 miles a day at least, increasing to 25 and 30 miles off Japan, and to 50 miles on its coasts. A velocity of 80 miles a day has been recorded.[2] Between 150° and 160° E., its strength has decreased to an average of 18 miles a day. The *Kamtchatka branch* has an average rate of from 7 to 10 miles[3] off the south-east of the peninsula, increasing to 14 miles and 30 miles[4] at some seasons in Behring Strait.

The cold current of the American coast is generally stronger and of a lower temperature than we should expect to find if it were solely caused by the North Pacific Drift in continuation of the Japan Current, so that it seems probable that it is partly formed in autumn and winter at least, by water flowing south into the Pacific through Behring Strait. Its rate is on an average 16 miles a day off San Francisco, and 14 miles on the South Californian coast, greater next the shore. The average maximum temperature of the Japan Current is 86°,[1] and the difference of its temperature from that of the ocean due to latitude is 12° Fahr. From its deep blue colour, as compared with the surrounding ocean, it has been called '*Kuro Siwo*,' or the Black Stream, by the Japanese. Its temperature gradually decreases to the eastward; on the Kamtchatka coast it was found to be 50°, and off San Francisco 60°. The cold current of the American coast increases rapidly in temperature as it moves to the southward, having been found to be *57°* in 37° N., *59°* in 30° N., and *72°* Fahr. in 22° N. latitude.

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[1] Montravel, Annales Hydrographiques, 1857.
[2] Naut. Mag. 1859. [3] Tessan. [4] Kotzebue.

South Pacific.

The currents of the South Pacific have a very close analogy to those of the South Atlantic. The Antarctic Drift, which gives rise to the South Atlantic Current off the African coast, causes a similar cold current where it reaches the west coast of South America. On meeting the South American coast, the great mass of cold water moving to the east-north-east is divided in about 45° S. latitude. One branch of it seems to be sucked backwards from this into the current which flows round Cape Horn; and the other, following the coast, forms the well-known *Peruvian*, or *Humboldt Current*.

Peruvian Current.

The *Peruvian Current* skirts the South American coast from this to near the Equator; its width narrows at the centre to about 120 miles, but expands to above 500 miles as it approaches the Equator, when turning to north-west and westward it becomes the South Equatorial Drift Current of the Pacific. Its rate is greater near the coast than at sea, and is on an average 15 miles a day about the Tropic of Capricorn, decreasing to 8 miles as it nears the Equator. The temperature of this current increases as it flows north, as is shown by the following table:—

Latitude.	*Temperature.*
Of Valparaiso, 33° S.	53°
30° S.	57°
Tropic of Capricorn,	64°
20° S.	65°
12° S.	66°
8° S.	69°
5° S.	74° on its western, and 66° on its eastern limit.

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[1] Naut. Mag. 1859.

South Equatorial Current.

The *South Equatorial Current* occupies the whole region of the South Pacific from 2° to 3° N. of the Equator, to about the Tropic of Capricorn, the western movement taking place generally at the rate of about 24 miles a day, though it has been observed to be as much as 60 miles. The mass of islands lying on each side of the 20th parallel of S. latitude, and between 130° and 170° W., seems to form a barrier to this current, diverting it north and south, as no appreciable current was found within this space.[1] The temperature of the South Equatorial Current increases as it moves to the east, having been found to be 77° in 115° W., *80°* in 130° W., *82°* in 150° W., and *84°* Fahr. in 172° E. The temperature of the sea has been estimated at from 9° in the west to 18° in the east lower than the current. In the western part of the ocean, where this current enters the monsoon regions, it is broken up into several branches, one of which passes down the east coast of Australia towards Tasmania, known as the *East Australian Current;* another branch passing south of the island of New Caledonia, sets north-west into Torres Strait; a third called *Rossel's Current* sets from the south of the Viti Islands, east of the New Hebrides, towards the north coasts of New Guinea.

East Australian Current.

The current off the east coast of Australia has a general S.W. and S.S.W. direction as far as Tasmania, where a small branch of it flows round the south and west coast of that island; and the main part turning south-east to meet the Antarctic Drift, returns with it to the eastwards into the Pacific. A periodical current, dependent on the monsoons, has been observed within 60 miles of the coast of Australia, running southwards from September to May close to the shore, and northwards outside, this order being reversed in the winter months.

The average rate of the East Australian Current is about 14 miles a day, and its temperature falls from about 70° in its centre in 31° S. latitude, to 60° in the latitude of Bass Strait, and 55° to the south of Tasmania. The average rate of the other branches of the South Equatorial Current seems to be about 10 miles a day, though off the south end of the island of New Caledonia, the north-westerly set has been observed at 48 miles.[2] The narrow passage of Torres Strait acts as a funnel for the concentration of westerly currents; the temperature of the water there is, on an average, 82°

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[1] Wilkes, U. S. Exploring Expedition, vol. v. 1845.

[2] Brown in Naut. Mag. 1868.

Fahr., or 6° higher than the corresponding latitude in the South Pacific, and 3° above that in the Atlantic.[1]

Within the Antarctic Drift, the Peruvian Current, and the South Equatorial Drift, there appears to be, as in the Atlantic, an inner temperate circulation of the waters of the South Pacific. The southern part of this flow is sometimes called the *Southern connecting or counter current*, and is partly caused by the meeting of the water of the South and East Australian Currents between Tasmania and New Zealand, partly by the north-easterly set of the Antarctic Drift, and partly by the returning to the south of a portion of the water brought west by the South Equatorial Current.

The rate of this counter current has been observed south of Tasmania and New Zealand to be as much as 40 miles a day on an average,[2] 29 miles in 160° W., and 17 miles in about 120° W. In 45° S. latitude the temperature of this current has been found to be 43°, and in 35° S. latitude as much as 65° Fahr. Bending round to the north and north-west, between 80° and 85° W. longitude, this inner circulation has the name of *Mentor's Current*, which merges again into the South Equatorial. This Mentor's Current appears to be quite distinct and separate from the Peruvian Current, and to be of a much higher temperature, observations in 53° S. latitude giving 72° on its western, 69° in its centre, and 67° on its eastern limit, whilst the temperature of the Peruvian Current, on the same parallel, is only 53° Fahr.

Equatorial Counter Current.

The *Equatorial Counter Current* of the Pacific crosses the entire ocean from west to east, between the parallels of 4° and 10° N. latitude, and is partly the drawback of the two currents flowing to westward on either side of it, in this corresponding exactly with the Guinea Current of the Atlantic, and partly, in the season of the south-west monsoon, formed by the waters driven out of the Indian Ocean through the channels of the East India Islands. The average rate of this current appears to be about 15 miles a day in its middle course, increasing as it moves to the west to 18 miles, but it has been observed to flow as much as 60 miles a day.[3]

China Sea.

In the China Sea, and in the channels of the East India islands, between the Pacific and Indian Oceans, the currents are entirely regulated by the monsoons, having a general *southerly* direction, modified by the outline of the coasts and passages, during the north-west and north-east monsoons from

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[1] Rattray in R. G. S. Journal. 1869. [2] Freeinet. [3] Krusenstern.

October to March; and a *northerly* set during the south-west and south-east monsoons from April to September. The rate depends on the force of the wind, and may be on an average 24 miles a day, though as much as 50 miles has been observed. A curious whirl or eddy in the monsoon current[1] is noticed in latitude 10° N. and 110° E., off the Asiatic coast, chiefly in the north-east monsoon, against which wind the outer part of the eddy sets strongly. The order of its motion is reversed during the south-west monsoon.

American Monsoon Current.

On the west coast of Central America, between 5° and 20° N. latitude, there is a monsoon current known as the *Mexican Current*, with a breadth of about 360 miles, flowing south-east from December to April, and north-west from May to December. Its rate depends on the force of the wind, and a counter current to it flows close to the shore.

Behring Sea.

In Behring Sea the current is always found setting to the *north* in spring and summer,[2] towards the American shores of the sea, drift-wood being abundant on this, and almost entirely wanting on the Asiatic coast. Augmented by the melting snow and ice, and water from the American rivers, it flows through the strait, and has been observed to have an easterly set along the American shores, at the average rate of 24 miles a day, but more or less dependent on the prevailing wind. A branch of this northerly current is also probably deflected along the Asiatic coast, since the observations recorded by Wrangell show a westerly current as far as the meridian of 140° E. in summer. In autumn and winter the current is found setting *south* into the Pacific on the American side of the sea, bringing drift ice as far south as the Eastern Aleutian islands, and probably giving its aid to form the cold current which flows down the west coast of North America.

Sea of Okhotsk.

In the Sea of Okhotsk,[3] the general direction of the flow of cold water is from north to south; south-west on the western side, and south-east on the eastern side of the sea, following the direction of the coast. The general drift is estimated at about 12 miles a day southward. Off the Asiatic coast north of the mouth of the Amur river, the south-westerly set has an average rate of 24 miles, and in the channels of the southern Kurile islands, extending from Japan to Kamtchatka, alternate south-west and south-east currents have been observed flowing at the average rate of 16 to 18 miles a day. This cold current flows south, mainly between the north island of Japan and Saghalien, but a portion of it seems to pass round the east coast of the north island. After flowing along the Asiatic coasts, and past the mouth of the Yellow Sea, this current is lost to view as a surface current in the Formosa Channel, but probably passes under the Japan Current, since a cold aqueous space has been observed between the meridians of 155° and 170° W., and the parallels of 30° to 35° N.[1]

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[1] Polack in Naut. Mag., 1868.

[2] Simpson, H.M.S. 'Plover;' Long, Naut. Mag., 1868.

[3] Montravel, Annales Hydrograhiques. Paris 1857

Cape Horn Current.

The *Cape Horn Current* is the binding link between the surface systems of circulation of the two great oceans. It is a contraction of the great north-easterly flowing Antarctic Drift of the South Pacific, and is sufficiently powerful to cause a re-suction of the north-easterly flowing waters in the South Pacific from as far as 45° S. latitude towards the Cape. Flowing east round Cape Horn this current has a breadth of about 180 miles; thence it turns north-east into the Atlantic, filling the whole southern part of that ocean to near 40° S. latitude, giving motion to the South Atlantic Current, and turning back the Agulhas Current to the Indian Ocean. Its average rate is about 15 miles a day in the Pacific, increasing as it is narrowed off Cape Horn to 24 miles.

The temperature of the Antarctic Drift in the Pacific, before turning south-east to form the Cape Horn Current, has been found to be 58° Fahr., on the parallel of the Strait of Magellan 49°, and off Cape Horn 41° to 42° Fahr.

A Universal Circulation.

These currents, however important to navigation and to the climate of the lands on which they touch, are after all only the surface motion of the waters; even the largest of the warm currents have been proved by the thermometer to be but shallow streams floating, as it were, on the surface, or at best cutting a shallow passage for their waters in the sea. But the deeper regions of the ocean are not and cannot be at rest, and there appears to be a univeral and regular circulation in the waters of the whole ocean throughout its entire depths, independent of the surface currents, some of which may indeed be aided by this general motion, or may form a visible part of it.

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[1] 'Mississippi' Naut. Mag., 1859.

We shall endeavour to trace the causes of this circulation. In the equatorial regions of the globe, the temperature of the waters of the ocean is found to *decrease* with the depth, to be warmest near the surface, and coldest at the bottom, with a generally regular diminution. At a certain point of latitude north and south of the equator, in the temperate regions, the temperature of the sea has been found to be *equal* throughout its entire depth from the surface to the sea-bed. Then beyond this latitude, towards the poles, the temperatures are found to *increase* with the depth, the coldest water being then on the surface, and the warmest below.

Temperature of the Sea.

The following table has been made from the recorded depth temperatures, chiefly of the Atlantic Ocean, by taking a mean of all those observed between each 10° of latitude, and at or near the depths indicated at the side of the table. Upwards of 700 observations have been used,[1] and the surface temperatures are the averages of those taken at the same time as the depth temperatures.

Depth in Fathoms.	*South*									*Equator.*								*North*
	Pole.	80°	70°	60°	50°	40°	30°	20°	10°	0°	10°	20°	30°	40°	50°	60°	70°	80° *Pole*
Surface	...	30°	30°	40°	53°	59°	76°	77°	79°8	79°8	77°	76°	72°	66°	50°	53°	29°7	32°5
100	...	33°	35°	40°	47°	54°	...	...	...	...	...	...	...	57°	49°	44°	29°5	...
200	...	34°	...	40°	...	...	...	...	69°	69°	70°	70°	65°	...	42°	45°	33°	...
300	...	35°	37°	40°	45°	49°	55°	...	...	...	...	...	...	55°	...	...	...	...
400	...	36°	38°	40°	43°	44°	52°	...	65°	64°	68°	66°	63°	49°	...	33°	...	31°
500	...	...	...	...	...	46°	...	...	...	...	...	...	...	39°	...	38°	...	...
600	...	38°	39°	40°	43°	42°	...	...	...	...	69°	63°	43°	...	...	46°	...	...
700	...	...	39°5	...	41°	40°	...	...	...	...	...	...	...	...	...	...	37°	...
800	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
900	...	...	39°5	...	40°	...	...	40°	...	...	...	...	...	...	...	...	...	...
1000	...	...	39°5	39°5	40°	...	...	...	...	...	...	...	37°	41°	40°	...	...	...
1200	...	...	39°5	39°5	39°5	...	...	39°5	...	...	...	...	...	...	...	...	...	...
1300	...	...	...	...	...	...	...	...	...	...	39°5	...	...	...	...	...	...	...
1500	...	...	...	...	...	...	...	...	...	...	...	...	...	49°	...	...	...	...
1800	...	...	...	...	...	...	...	...	...	...	39°6	...	...	...	...	...	...	...
1900	...	...	...	...	...	...	...	...	...	...	33°5	...	...	...	...	...	...	...
2000	...	...	...	...	...	...	...	...	...	...	...	...	...	42°	...	...	...	...

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[1] The authorities for these are: Ross' Southern Seas; Lee, U.S.N. 'Dolphin'; Chimmo, in R.G.S. Journal, 1869; Carpenter and Thomson's soundings in the seas north of British Isles, 1868; Scoresby, Franklin, Parry and Fisher, Dayman, Shortland, and Voyages of 'Adventure' and 'Beagle.' In reference to this table it must be admitted, that observations of deep sea temperatures require to be made with a thermometer having its bulb protected from the enormous pressure of the water at great depths, otherwise the readings are too high, and such an instrument was only invented in 1869; but if the previously recorded temperatures at great depths in the polar regions be too high, those in the tropical seas must likewise be reduced.

It is obvious that with these conditions of temperature and the existing surface currents, the waters of the ocean cannot be at rest; and there are two apparent causes of motion.

The first of these is the diminution of density, by expansion through heat, of the surface water in the tropics, causing it to overflow on each side of the equator *towards the temperate regions*, and necessitating a constant upward supply of cold water from below. In noticing this part of the universal circulation, Buff, in his 'Physics of the Earth,' says—'The water of the ocean, at great depths, has a temperature, even under the equator, nearly approaching to the freezing point. This low temperature cannot depend on any influence of the sea bottom. The fact, however, is explained by a continual current of cold water flowing from the polar regions towards the equator. . . . The water that is cooled at the polar regions sinks and travels from the poles to the equator, pushing away the warmer and lighter fluid from the bottom of the sea, itself to give way in turn as it gets warm, to the colder water that follows after it. The warm water of the tropical seas, since it is the lightest, must spread itself north and south over the surface of the ocean.'

But this points only to one-half of the movement; for in the polar regions, the waters, after being reduced in temperature to perhaps 28° Fahr., begin to expand and decrease in density, when congealing into ice, thus becoming lighter, besides being freshened at one pole by quantities of water from the great Arctic rivers. The ice, in melting at the edges of the polar circles, pours a flood of lighter water, of much less salinity[1] than the general ocean, *towards the temperate regions*, bearing pieces of the ice with it, which, in melting, tend to keep up the lighter character of this overflow. This second upper flow must also be supplied from beneath, but this time with warmer water, at a greater density. Thus there seems to be established a *figure of eight* circulation in the waters of the ocean in each hemisphere (see diagram at the foot of Map 15), an upper and an under warm, and an upper and under cold flow, meeting[2] and interlacing at the temperate zone, where, as before noticed, points have been found at which the temperatures of the sea are equal throughout its entire depth. The most visible part of this universal circulation is in the Antarctic region, the part of the ocean least disturbed

Colder and Warmer Parts of the Circulation.

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[1] Prof. Forchhammer, of Copenhagen's investigations.

[2] The cold and warm areas of the sea bed, discovered side by side during Carpenter and Thomson's scientific cruize, in the channel between Scotland and the Faröe Islands, 60° N. lat. (summers of 1868 and 1869), apparently mark the meeting place of the under circulations there.

by the intervening land, from which we find a cold current flowing outwards on every side, with no apparent supply.

The Arctic region has not the same freedom for the display of this circulation, since it is hemmed in on three sides by the continents of Asia and America, and only communicates freely with the ocean in the wide channel between Europe and Greenland; but here also there are strong evidences of its existence. First, then, we have the constantly southerly tendency of the ice, whether in large masses into which ships have been frozen, or in pack ice or icebergs; no one has ever found the ice moving to northward. Whence, then, does the supply of this ice come? At a certain line we find the ice constantly *melting*; must there not then also be an open space of water within the polar area, round which the ice is as constantly *forming*; the disputed '*Polynia*' of Arctic explorers. The existence of this open sea is the more probable, if the presence of the warm underflow be allowed, for the waters rising from beneath, would arrive at the surface at too high a temperature[1] to change into ice at once, and would overflow a considerable space of the sea beneath the cold atmosphere, parting with warmth slowly, before their temperature could be reduced to the freezing point. In the Arctic region, then, we have apparently a central open sea of variable extent, with warmer waters constantly welling up in the middle of it, bounded by a line of ice forming nearer the central supply of water in the long winter, and farther from it in summer, when the heat derived from the unsetting sun must aid the underflow in widening the sea; and beyond that a belt of ice surrounding the continental shores of the ocean, and extending to the melting line, between Asia, Spitzbergen, and Greenland. The only exit for the great masses of ice which form round this open sea being towards the Atlantic, it is on this side of the Arctic basin that we must look for the greatest breadth of the barrier of ice which has hitherto prevented access to the pole. The way to the pole then seems to lie, not across this broader barrier, which, constantly moving to southward, has hitherto baffled hundreds of expeditions, but either across or through the narrower and more stable

The open Polar Sea, or 'Polynia.'

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[1] Scoresby, 1822, mentions an increase of temperature of 7° found in 100 fathoms in 79° N. latitude off the east coast of Greenland; and in another series of trials, near the same place, an increase of 8° in 730 fathoms, and attributes the increase to a warm under current; and Franklin, in his 'Polar Seas,' 1823, says, 'Between Spitzbergen and Greenland we invariably found the water brought from any great depth to be *warmer* than that at the surface.

belt of ice next Behring Strait (which is probably broken up in summer when the warm current runs in from the Pacific), into the open water, returning with the surface motion, which would certainly bear a vessel, whether frozen into the ice or not, to the Atlantic.

The universal circulation of the ocean bears a striking resemblance to the great normal movements of the atmosphere, though the former is limited and confined by the land, and its interchanges take place at a much less rapid rate than those of the lighter and unrestrained ocean of air which lies above it; but with these differences, the trade winds may be compared to the under or colder flow of the waters of the sea towards the equator, and the anti-trade winds to the warmer under tide towards the polar regions.

The Circulation between air and ocean.

Besides this apparently common motion, the oceans of sea and air are bound together closely by another system of circulation, without which the land of our earth would be a barren and burnt up desert. By the constantly active process of evaporation, the air draws up minute particles from every watery surface; this vapour is carried through the air by the winds, till, on becoming suddenly cooled and condensed by whatever cause, its particles uniting, descend the earth's surface as rain. The rain-drops which fall on the land then unite in rills and brooks to form streams; these again joining form rivers, which, flowing down to the sea, restore to it the water drawn up by the air, so completing the circulation.

Rain.

The rainfall is greatest where there is an ascending current of vapour from a water surface: so the almost constant rains of the equatorial belt of calms in the Atlantic are caused by the upward passage and condensation of the saturated air, which has been carried across a great part of the Atlantic by the north-east and south-east trade winds; and again, in the interior of the continents, in those parts which are reached by winds which pass overland from a colder to a warmer area, and so become constantly drier as they advance, there occur great areas which receive little or no rain, and in these there are consequently no permanent rivers. The total want of rain in the Sahara of Africa seems to be due to this, that the prevailing winds are drawn into it from the northward over Asia, and their moisture is in great measure lost before they reach the African continent; and besides that, in the Sahara there are few elevations to condense the vapours: where these do occur there is a rainfall; and though there is an ascending current over Central Asia in summer, yet the winds flowing into this spend their moisture on the outer margins of the continent; in winter there is a descending pressure, and the winds flow outwards from the dry interior. Seeking everywhere the lowest level, the rivers flow down the slopes of the continents from the higher to the lower ground till they reach the sea, and so their courses, when mapped out, give the surest delineation of the general form of the land, for a steep and narrow descent to the sea is marked by short and rapid rivers, whilst on a long and gentle slope the rivers become great by receiving many tributaries, and flow smoothly through their long course to the ocean. We have seen in Maps 3 and 4, that the great highland of the globe lies round the Pacific and Indian Oceans, whilst the great plain of the world slopes gently down to the Atlantic and Arctic Seas. From this cause, the extent of the land slope which is drained to the Pacific and Indian Oceans, is only half of that of the great plain which sends its rivers to the Atlantic and Arctic Oceans, and whose drainage basin occupies more than one-half of the whole land of the globe.

Between different parts of these two great divisions are the areas of continental drainage, which return no water directly to the sea. These areas are generally in the central parts of the continent, sometimes depressed below the general level, and having little rainfall have few rivers, and so are in great part desert. Where there are considerable rivers in the areas of continental drainage, as in Africa and in Central Asia, these terminate in great lagoons or inland seas, and the greatest of these inland seas is the Caspian, the one which receives the largest continental river. The following are the areas of the river systems belonging to each of the oceans, and of the continental systems of the world.

	Square miles.
Area draining to the Atlantic Ocean, . . .	19,050,000
,, ,, Arctic Ocean, . . .	7,500,000
Drainage area of the great plain of the world, . .	26,550,000
Area draining to the Pacific Ocean, . . .	8,660,000
,, ,, Indian Ocean, . . .	6,300,000
Drainage area of the outer slope of the great highland of the world, ...	14,960,000
United areas of continental drainage, . . .	10,673,000

THE BASIN OF THE ATLANTIC.

MAP 17.

THE Atlantic Ocean occupies the greater part of the vast trough or valley which, stretching from pole to pole, separates the eastern from the western world, and forms perhaps the deepest hollow in the crust of the globe, containing the longest sea on its surface.

The bed of the Atlantic would seem to have been made by some terrible force, which rent the surface land asunder, but left the edges of the ravine to show, by their form, that they had once been connected; so the British Isles appear to fit into Davis Strait, the projection of the American coast at Newfoundland to correspond to the Bay of Biscay, the rounded mass of Western Africa to the vast gulf between North and South America, outside of the West Indies, and the eastern corner of the South American continent to the Gulf of Guinea.

Limits and Area.

The limits which have been assigned to the Atlantic Ocean are —besides the continents of the Old and New World —the Arctic Circle on the north, and the Antarctic Circle on the south; whilst the meridian of Cape Horn, an imaginary boundary, separates it from the Pacific on the west, and that of Cape Agulhaz, from the Indian Ocean, on the east. Within these limits, and to the north of the equator, the ocean has numerous branches or inlets into the land: in the Caribbean Sea, Hudson Bay, and Davis Strait on the west, and the Baltic and Mediterranean on the east; but south of the equator its coasts are more even. The whole connected water-surface of this ocean covers an area of 35,165,000 square miles, or a little less than one-fifth part of the entire surface of the globe.

Contours.

The map of the Atlantic, which is given here, has been worked out in the same system of contours as the other hypsometrical maps in the Atlas, with this difference, that whilst the larger scale maps have been prepared in contours of parts of a mile, the whole mile has been taken here to represent the height and depths, a measure more worthy of the magnitude of the subject. The waters which form a part of the Atlantic Ocean, are coloured in deepening blue for the deeper water; and only those parts of the land which belong to the Atlantic basin have been coloured, in shades of brown, according to their height. The contour lines are of one and two miles on the sea and on the land, so that the light brown colour on the land corresponds to the first tint of blue in the water, the land rising to one mile from the coast, and the sea-bed sloping down to that depth; the darker brown colour, above one mile in height, agrees with the second tint of blue, below one mile in depth: whilst the comparatively minute black patches above the darker brown, represent the small area of land above two miles in height which drains to the Atlantic, and correspond with the large mass of deep blue which represents the area of the bed of the Atlantic which is below a depth of two miles. The contrasts of height and depth are here very striking. A very narrow strip round the margin of the sea-bed shows the small part of it which is less than one mile in depth, whilst by far the greater portion of the surface of the continents draining to the Atlantic, are not over this height. The darker brown patches on the land, above one mile in height, form together a very insignificant area in comparison with that which is enclosed in the Atlantic as being below this depth, but the contrast is most striking when the small black spots which represent the highest parts of the land are compared with the great area of more than half the ocean, which is at a corresponding depth.

Form of the Sea Bed.

A thorough knowledge of the earth comprehends the form of its surface as well below as above the surface of the sea; and this knowledge of the depths of the seas is not alone useful in its bearing on other physical conditions of the globe, but has recently become a practical necessity in determining the course of submarine telegraphs; yet the only part of the vast sea bed which has been at all explored is that of the North Atlantic. The main features of this part of the ocean-bed have now been mapped from a great number of soundings with tolerable accuracy.[1] Southward of the equator the soundings which have been made are very few and distant, so that the form of the sea bed here, excepting round the coasts, is still almost entirely a matter of conjecture.

One Mile in Depth.

In the North Atlantic the contour line of one mile in depth, skirts the northern shores of South America, and passes outside the chain of the West Indies without breaking through their barrier to the coasts of North America; it follows round these coasts at the same average distance, till it is carried far to seaward outside the shallow banks of Newfoundland. Then we trace it along the Labrador coast, and to some distance into Davis Strait, thence round the coasts of South Greenland and up into the Arctic Sea, to near the parallel of Iceland; southward again round a long projection of less depth, and across to the shores of the British Islands. Here it marks the edge of the plateau on which these islands rest, then passes to the Bay of Biscay and to the coasts of Spain and Africa, maintaining a more equal distance from these. There are several isolated parts of this line of a mile in depth; two are within the line of the West Indies; the first surrounding a hollow, which extends in the bed of the Caribbean Sea from near the Isthmus of Panama to the Island of St Thomas, and a second which shows a depression in the Gulf of Mexico, between the mouths of the Mississippi and the Island of Cuba. There are three such isolated hollows in the Mediterranean, and one in the Black Sea, marked out by this line; and in the open ocean, the line of a mile in depth surrounds numerous islands, which tower above the lower depths of the ocean. Such mountains in the sea bed are the Bermudas, the Azores, and the islands off the coasts of Africa. A large isolated area to the west of the British Isles, capped by the little islet of Rockall, is of a less depth than one mile.

Two Miles in Depth.

The contour line of two miles in depth, brings out the great feature of the North Atlantic Ocean bed, the vast plateau which extends through it. It passes from the equator round the South and North American coasts, parallel to the line of one mile of depth, showing a regular and rapid slope from this coast line; but, arrived at the south of Greenland, it turns suddenly southward, and marks out the irregularly shaped plateau, which stretches from this through the midst of the sea bed, to as far south as the latitude of the West Indies. A long valley, extending from south-west to north-east, cuts deep into the plateau between Newfoundland and Rockall bank, and leaves it attached to the shallower part of the sea-bed to the north, only by a narrow isthmus. It is over this valley and isthmus in the plateau, that the two telegraph cables. uniting Ireland with Newfoundland, pass across a distance of 1850 English miles. The French cable from Brest passes for 3330 miles from shore to shore, and across the plateau further to the south, since its course is in a curve south-westwards from its starting point in western France, to the corner of the bank of Newfoundland, from which it turns north-west to the island of Saint Pierre. Beyond the plateau, the line of two miles in depth follows close round the south-western part of the plateau of the British Isles, showing that this ocean highland has an almost precipitous descent on this side, then round the Bay of Biscay and the Spanish coasts, and along the African side of the sea bed, outside the Canary and Cape Verd Islands, to the equator in the Gulf of Guinea. Isolated parts of this line surround the base of the ocean peaks of the Bermudas, Madeira, and St Paul, which stand at the corners of a nearly equilateral triangle in the midst of the ocean, and are solitary peaks, rising from the sea bed to a greater relative height than almost any of the mountains on the land.

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[1] The contours of the North Atlantic have been adapted from those on the chart of the North Atlantic, by Hermann Berghaus, in Stieler's Hand Atlas. This chart is based on the former one by Maury, and is the latest and most accurate representation of the North Atlantic sea bed extant.

Greatest Depth of North Atlantic.

A still deeper area, which might be shown by a three mile contour on the Map, extends from near the island of St Paul, on the equator, towards the Bermudas, forming a huge valley, which bends round between the latter islands and the American coast, into the deepest area of the Atlantic; this lies in the space between the American coast and the plateau of Newfoundland on the north, and the central plateau and the Bermudas on the east and south. A large portion of this area is supposed to be more than four miles in depth, whilst one sounding, midway between the Azores and Bermudas, gives 6600 fathoms, or seven and a half English miles.

The recorded soundings in the South Atlantic are so few in number, and so wide apart, that no representation of the sea-bed can be made with any pretension to accuracy. The American coast, south of the equator,[1] does not seem to descend so steeply as the general coasts of the northern part of the ocean; and a large portion of the sea bed off the South American coast, included in a line drawn from Rio de Janiero, to the eastern part of Tierra del Fuego, with a projection embracing the Falkland Islands, is not over one-eighth part of a mile in depth.

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[1] French Charts of Brazilian Coasts.

A few soundings would seem to show that there is a great ridge or plateau in the midst of the South Atlantic also, extending from beyond the Island of St Helena on the south, past Ascension, to a shallow area just below the equator, on the 20th meridian, which has been found to be only from 300 to 800 fathoms below the sea level. In this shallower area frequent temporary shoals, upward shocks of earthquake, and other phenomena, give evidence of submarine volcanic action. The Islands of St Helena and Ascension form the culminating points of this supposed South Atlantic plateau, and it is probable that a second and parallel ridge unites the lower structures of the Islands of Tristan da Cunha and Gough, further to the south.

Greatest Depth in South Atlantic.

Several doubtful soundings, in longitude 40° W. off the Rio de La Plata, give enormous depths, one as much as 8300 fathoms, or nearly nine and a half English miles. If this measurement were accepted as the depth of the greatest hollow in the earth's crust, then the limit of the undulation of the surface of the globe would be fifteen English miles, since the highest summit of the land is nearly five and a half miles above the level of the sea. But from the great uncertainty which attends sounding in such vast depths, from the probabilities of the action of under-currents on the sounding-line, in curving it perhaps in several directions, and in carrying the lead away from the vertical direction, we are scarcely warranted in taking a depth of more than five or six miles as actually proved. This would give the undulation of the earth's crust a vertical limit of about ten English miles, or one three hundred and ninty-fifth part of its radius.

The surface of the sea may then be taken as a middle point between the absolutely most elevated and most depressed parts of the earth's surface; but, at the same time, it must be borne in mind, that the cubic mass of the water far exceeds that of the land which appears above its level;[1] and it appears that, if the water were removed from the bed of the North Atlantic, the whole mass of land on the surface of the globe, which is above the sea level, if turned into it, would not fill up much more than a fourth part of the valley. Careful measurements of the areas of the North Atlantic sea-bed, which are at successive depths of 1000 fathoms, give the following results:—

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[1] See Map 2, Land and Water.

	Fathoms.		*Square Miles.*
Area[1] of the North Atlantic between the coast line and	1000	=	7,219,800
,, ,,	1000 and 2000	=	3,854,550
,, ,,	2000 and 3000	=	4,873,950
,, ,,	3000 and 4000	=	2,228,800
,, ,,	4000 and the greatest depth,	=	252,500
	Area of the Atlantic north of the Equator,		18,429,600

Then assuming the average depth of each of these areas to be equal to the midway depth between the fathom lines which mark them out, we have the Cubic Mass of Water of the North Atlantic at an average depth of:—

Miles.		*Cubic Miles.*
0·568	=	4,100,850
1·704	=	6,568,150
2·840	=	13,842,020
3·977	=	8,863,940
5·113	=	1,291,030

The total cubic space of the North Atlantic valley is then = 34,665,990 and dividing this mass by the area, we obtain 1·88 miles as the *average depth* of the North Atlantic.

The land of the Atlantic Basin.

The land draining to the Atlantic Ocean comprises the greater part of Europe, more than half of Africa, the whole of South America with the exception of a narrow strip on the western side of the water-parting of the Andes, and a large area of North America. The whole area draining to the Atlantic covers a space of 19,045,000 miles, divided thus:—

	Square Miles.
Area of land in Europe draining to the Atlantic,	2,420,000
,, Africa ,,	5,614,000
,, South America ,,	6,056,000
,, North and Central America ,,	4,683,000
,, Greenland and Islands ,,	272,000
Total,	19,045,000[2]

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[1] The lines from which the above areas are measured were drawn on a globe of 30 inches in diameter, from the chart of the Atlantic sea bed, by Berghaus, before noted.

[2] These figures, as well as the area of the Atlantic Ocean, are original measurements from the gores of a thirty inch globe.

By far the greater part of this area is much *below* the height of a mile, and the contour of this amount marks out only the most elevated mountains and table-lands. The largest area *above* this elevation occurs in North America, in the plateau between the Rocky Mountains and the coast ranges on the west, which extends into the table-land of Mexico; a narrower belt of land, above a mile in height, is formed by the Andes of South America; the next highland in extent belonging to this basin, is that of the plateau of Abyssinia, in Eastern Africa; and in Europe, among many smaller isolated mile heights, the most extensive are those of the mountains of Asia Minor and the Alps.

Areas of a greater height than two miles, on the land which drains to the Atlantic, are represented by small black patches on the Map, and present the greatest possible contrast to the huge depression of the sea-bed, which is below two miles in depth. There are few such points in all on the Rocky Mountains of America and on the table-land of Mexico, in the Alps of Europe and in the table-land of Abyssinia; the greatest area above this height is only a very narrow line of heights along the tops of the Andes of South America, the highest part of the basin.

The greatest Rivers of the World drain to the Atlantic.

The Amazon, the greatest river of the world, draining an area of nearly two millions of square miles, flows directly to the Atlantic; but the two rivers next to this in the extent of their basins, the Nile and the Mississippi, drain to the mediterranean seas on the east and west sides of the ocean. The latter reaches the Mediterranean from behind a vast isolated and almost riverless region in the interior of North Africa, from which no water reaches the sea.

Traffic on the Atlantic.

The Atlantic is a vast highway of commerce, and bears on its waters the greatest fleets of merchant and passage vessels. There are certain great lines of traffic on its surface, almost as well known and as regularly passed over as any highway of the land, radiating out over the ocean from the channels of the seas in the west of Europe, and from the eastern coasts of North America. These courses vary a little according to the season, being affected by the periodical changes in the direction or strength of the winds, and the presence or absence of obstructing ice in winter or summer. One of these lanes, perhaps the most frequently travelled of all, is that between the British Isles and the harbours of America, on the opposite coast, which has been sailed over in less than thirteen days and crossed by steam in five days; other highways spread to the West Indies, to the ports of South America, through the ocean round Cape Horn from Australia, or the Cape of Good Hope for India or China, to the Mediterranean, or to the Baltic and White Seas, whilst a special set of vessels penetrate beyond the Atlantic on the north into the Arctic regions, to carry on the adventurous whale fishery. But besides the traffic on these ocean highroads, the sea is crossed in every possible direction; and smaller vessels keep up a constant movement round the shores of the continents and in the narrow seas. An idea of the magnitude of this intercourse may be formed from the fact, that nearly 60,000 vessels enter the ports of the United Kingdom in the course of a year.

Limits of Traffic.

The whale fishery carries regular summer traffic far into the Arctic regions of the north, to the 75th parallel of latitude; but, in the South Atlantic, no traffic ever penetrates the Antarctic Circle, or extends beyond the 50th parallel of S. latitude, except where a greater southing is required in rounding Cape Horn into the Pacific, since the navigable part of the sea which lies beyond this is not in the line between any two centres of intercourse.

Cold and Warm Sides of the Ocean.

The Northern Atlantic has a cold side and a warm one, between which, though they are in the same latitude, there is an average difference of 20° of temperature. The western coasts of Europe are on the warm, and the eastern coasts of America on the cold side of the ocean; the average temperature of the American side is slightly below the normal temperature due to latitude, but the temperature of the European side is far above that which its position on the surface of the globe would give it, if there were no other causes at work. The great cause of this increased temperature on the western side of the Atlantic seems to be the prevailing anti-trade wind,[1] which almost constantly carries the atmosphere of warmer latitudes to the west of Europe and across the open plain of the sea to the northward, besides rolling on before it a surface drift of warmer water continuing the Gulf Stream.[2] This warmth carries the limit of drift ice far to the northward on this side of the ocean, beyond the Atlantic into the Arctic Sea, leaving the waters clear; but on the opposite side, where the average

Limits of Ice.

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[1] For the Winds of the Atlantic, see Map 22.

[2] See Maps of Ocean Currents, 15 and 16.

temperature is already somewhat below the normal amount, a cold current from the Arctic regions carries the drift ice far to the south of the latitude of the British Isles, and across the lanes of traffic to beyond the Newfoundland banks; and icebergs at their farthest southing on this side reach the latitude of New York or Madrid. The average limit of pack ice, which is constantly moving to southward along the eastern coasts of Greenland, is in a line from Spitzbergen to outside Cape Farewell, thence round the coasts and into Davis Strait, turning to the north point of Newfoundland and blocking up the coasts of Labrador.

Drift ice reaches generally much nearer to the equator in the South Atlantic, since the cold Antarctic current overspreads the greater part of the ocean, and its limit is generally the 40th parallel throughout, from the Cape of Good Hope to the westward; but off the mouth of the Rio de la Plata, the limit line is carried southward, to outside of the Falkland Islands and Cape Horn, by the warmer waters which seem to cover the shallower parts of the sea bed, next this coast. The average limit of pack ice in the South Atlantic seems to correspond nearly to the Antarctic Circle.

Sections.

In the corner of the Map are several sections of the bed of the North Atlantic, drawn to the horizontal scale of the Map; but the relative depth has been greatly exaggerated, since, without enlargement, the undulations would not be visible on such a small scale. The first represents the form of the sea bed, between the west of Scotland and Cape Farewell in the south of Greenland. In it the rise of the Rockhall bank is to the right, and that of the long submarine peninsula, which stretches southwest from Iceland, to the left of the section. The next shows the undulating part of the floor of the Atlantic on which the Atlantic cables have been laid. A third section crosses the middle of the great ocean plateau in a line from Newfoundland to Africa; and the fourth, in a line from Newfoundland to South America, shows first the shallow Newfoundland bank, then the deepest part of the ocean, rises in crossing the plateau, sinks again beyond it, and slopes up gradually to the American shore.

THE MEDITERRANEAN.

MAP 18.

THE *Mediterranean Sea*, or the Sea Amidst the Land, is that great branch of the Atlantic Ocean which lies between Europe on the N., Africa on the S., and Asia on the E. It is connected with the Atlantic by the Strait of Gibraltar, and with its tributary sea, the Black Sea, by the Sea of Marmora, and the two straits at its extremities—the Dardanelles and the Bosporus. The Mediterranean area presents, perhaps, the most interesting combination of physical features of any region of the globe. The Map given in this Atlas, is intended to be as complete a guide to the physical geography of this sea, and of the country immediately surrounding it, as is possible on the small scale allowed, and shows its elevations and depressions above and below water; its winds, currents, and fresh springs; its climate, chief products, and volcanic phenomena. Space only admits of a notice, in a few words, of the leading points under each of these heads.

The *contour lines*, adopted to show the elevation of the land and the depth of the sea, are of half-a-mile, and one mile, it being believed that the idea of heights and depths of these amounts is more readily grasped than if they were stated in a certain number of feet.[1]

Highlands.

The more elevated parts of the land to the east of the Mediterranean, are the heights of the Caucasus, the great plateau of Asia Minor rising highest in the Taurus Mountains on the south, and stretching into Syria in the Lebanon ranges, and the mountains beyond the Dead Sea, forming the eastern barrier. On the north are the mountains of Turkey and Greece and the Apennines, inclosing the Adriatic, and meeting in the Alps, which show the largest area above one mile in this region; the Pyrenees, and the table-lands of north and east Spain, and south of these the parallel sierras, the southmost of which bends round to close in the western entrance to the sea at the Strait of Gibraltar. On the south side of the Strait we find the termination of another enclosing range leading into the great highland plateau of North Africa, which stretches from Marocco through Algeria to Tunis, and which rises only in one narrow range on its western extremity to above one mile in height. From Tunis to Lower Syria the African coast region never rises above half-a-mile, but the land is not low excepting in the great plain of the Nile delta.[1] To the east of Syria and Asia Minor begins the great valley of the Euphrates and Tigris; on the north of the Black Sea are the plains of South Russia, and to the west of it the valley of the Danube extends into Central Europe. Further west we come to the plains of North Italy and of Western France, and to the valley of the Ebro in North East Spain.

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[1] These contour lines have been worked out originally for this map, at great labour, at first on a large scale, and then reduced to the present map.

Lowlands.

The following quotation from Admiral Smyth's work on the Mediterranean, describes its great divisions:—'The northern and southern shores of the Mediterranean are greatly contrasted in feature; the former expanding into peninsulas, isthmuses, sinuosities, and islands, while the configuration of the latter presents comparatively but little articulated variation of form. Exclusive of the Black Sea, which, however, must be considered as a part of it—this sheet of water is naturally divided into two vast basins; and these again are subdivided into particular portions. The *first great basin* extends from Gibraltar to Cape Bon, and the Faro of Messina, washing the bases of the Pyrenees, the Alps, the Apennines, and the range of Mount Atlas; and it is again subdivided into two unequal parts by the islands of Corsica and Sardinia. The *second or inner grand basin* extends from the coasts of Tunis and Sicily to those of Egypt and Syria, stretching on to the north into two distinct and separate basins, known as the Adriatic and Archipelago; while on the south the Gulf of Libya (Cabes and Sidra) penetrates deeply into the

Divisions.

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[1] For Syria, the Dead Sea depression, and Nile delta, *see* Map 13 and notes.

African continent. The eastern portion of this basin is interrupted by Cyprus alone, and is now universally known as the *Levant*, a term, however, more proper for its coasts than its waters.'

Depths. A submarine ridge extends between these basins from Cape Bon in Africa to the S.W. corner of Sicily, with a less depth of water over it than 100 fathoms. The greatest depth in the western basin is probably from 1500 to 1600 fathoms (1·8 miles), and in the eastern 2100 fathoms (2·4 miles) between Sicily and Candia. In the Black Sea the greatest depth is perhaps not much over 1000 fathoms (1·1 miles). The contrast between the very small area of land above one mile round the Mediterranean, and the great area of its bed which is below this depth, is remarkable. The greater part of the Adriatic is of a less depth than 100 fathoms, or an eighth part of a mile, and only a small part of the Ægean Sea above Candia, reaches half-a-mile in depth. The Balearic Isles, Corsica and Sardinia, Candia and Cyprus, stand curiously at the termination of submarine peninsulas, connecting them with the mainland.

Currents. The *currents of the Mediterranean* are very subject to the influences of the winds, but in settled weather a strong current enters the sea from the Atlantic, moves along the north coasts of Africa eastwards, passes the Nile delta, and bends northwards along the coast of Syria, round Cyprus, setting into the Gulf of Adalia, and thence across the lower parts of the Ægean, between Candia and Greece, where it is joined by the general southerly current from the Black Sea. After passing Greece, the *Mediterranean current* seems to divide, and to be partly reflected, first south and then eastward, setting towards Africa again, in the direction of the main current, but with much diminished force; and partly to go to form the *Adriatic current*, which runs round the eastern shores of that sea, sweeps past Trieste and Venice, and thence out again by its eastern shores. In the western basin of the Mediterranean, a current sets round the south-east coasts of Spain, from the Strait of Gibraltar, probably divides at the Balearic Isles, passing partly to the south of them, and partly to the north, towards the Gulf of Lions. A branch of the *Mediterranean current* seems to be deflected by the western corner of Sicily, and to set between the Islands of Sardinia and Corsica, and Italy, to the Gulf of Genoa, where it turns with the coast, first west then south-west towards the Gulf of Lions, and, meeting the before-mentioned current from the Straits, passes south with it towards Africa.

The normal *current of the Black Sea* begins at the outfall of the River Don from the Sea of Azov, sets round the Crimea westwardly, is turned south by a current from the Dnieper and Dniester, which two now meet a third from the Danube, and then, all united, rush towards the Bosporus, forming the Sheitan akindí-sí, or Satan's current, flowing into the Sea of Marmora, and thence, though less strongly, through the Dardanelles into the Ægean. The Bosporus is not broad enough to admit all the waters of the Black Sea current, so that a large portion of it is diverted to the eastward, and passes round the coast to rejoin the current from the Sea of Azov. In the Strait of Gibraltar, the *constant current from the Atlantic* has a general velocity of 2 to 3 miles per hour at its centre, and outside the African capes of 1 to 2 miles; between Malta and Tripoli the easterly current runs at 1½ miles an hour, and on the Syrian coast from 1 to 1½ miles. The *Adriatic current* often attains the rate of 1 mile per hour. The general strength of the current in the Gulf of Genoa is not above 5 miles per day.

The question of what becomes of the great mass of water which constantly pours into the Mediterranean has never been definitely settled, some authorities maintaining that the greater part of the water is carried off by evaporation, others accounting for it by an undercurrent in the Straits. Perhaps both influences may have a share in the work, but the former seems the more tenable theory. The waters of the Atlantic, which pour into the Mediterranean, are a part of the return current of the Gulf Stream, coming from the North Atlantic, where they have been cooled down, and so may be supposed to have a lower temperature than the ocean generally in this latitude. To pass out below this Atlantic water as an undercurrent, the water of the Mediterranean must be either of a still lower temperature, or of a greater density, neither of which conditions are easily conceived, when we remember that the mean annual temperature of the Mediterranean is higher than that of the region in the Atlantic from which it is supplied with water; and that, besides the numerous fresh springs which exist in its basin, the rivers of an area of upwards of two and a-half millions of square miles are constantly pouring fresh water into it.

Fresh Springs.

Ten fresh springs in various parts of the Mediterranean Sea, near its coast, are enumerated by Admiral Smyth. They are more or less copious, but some are 'subterranean rivers, bursting up with amazing volume and force.' The position of each is indicated on the map.

Winds.

The Mediterranean appears to be swept for the greater part of the year by the winds drawn towards Africa from the northward, over Europe and Asia, the exceptional winds being the hot blasts from the Sahara southward. The winds of this interesting region are, however, not yet satisfactorily observed and discussed.

The *cold winds* blow chiefly from the N.W. in the western Mediterranean, and from the N.E. in the eastern division, with more or less force during the greater part of the year. The chilly wind blowing down the valley of the Rhone, and over the Gulf of Lions from the N.W., is the '*Mistral*' of that district, and the '*Maestrale*' of the Island of Sardinia,—reaching Palermo as a refreshing sea breeze it is called '*Marmatili*.' The N.E. wind, in the eastern division, takes its rise in the steppes of Russia and Western Asia, and is termed '*Poyraz*' in Turkey, '*Etesiæ*' (or Etesian Gales) in the archipelago. '*Gregale*' at Malta and on the east coast of Sardinia, and '*Tramontane*,' in Italy. This wind seems to become concentrated at particular points of the coasts of the Mediterranean in occasional violent blasts. The best known of these are the '*Bora*' (Boreas) of the northern Adriatic and Dalmatia, which occurs at all seasons, but specially in winter; the fierce gusts called '*Raycas*,' occurring in the N.E. corner of the Levant at Alexandretta, and the '*Orsure*' of the Gulf of Lions.

The *hot winds* of Africa are most prevalent in spring and autumn, but are not confined to these seasons; they are slightly felt as far as the northern shores of the sea.

The hot wind is most widely known in the Mediterranean as the '*Scirocco*,' but the '*Samiel*' or '*Khamsin*,' or '*Qh'ramseen*' of Egypt (so called from its blowing generally for fifty days from the end of April till the inundation of the Nile) and the '*Samoom*' of Arabia, are the same wind with different names. The '*vent d'Espagne*,' felt in the French valleys of the Pyrenees, the '*Fohn*,' the warm winter wind which melts the snows of the Alps, and the '*Yong*' of Croatia, are all probably to be traced to the same source. The '*Solano*' or '*Levanter*' of South and Eastern Spain, and the Straits, blows strongly from the east, not in any particular season, but lasting for as much as fifteen days at a time, and is described as a hot, suffocating wind, loaded with fine dust, in summer, while in winter it brings rain and showers. It is perhaps formed by a union of the north-east with the hot south-east winds of Africa, taking its character from the greater strength of one or other of these. South west gales, called '*Vendavales*,' prevail in the winter months on the south-west coasts of Spain, and seem to extend into the western basin of the Mediterranean, and to the Adriatic, where the vehement but short lived south wester is known as the '*Siffanto.*' The '*Bentu-de-soli,*' a warm east wind in the neighbourhood of South Italy and Sardinia, is loaded with vapour and accompanied by lightning, and the '*Vento del golfo,*' at the Gulf of Corinth, is also a warm and disagreeable local wind, which begins a little after midnight and lasts till nearly midday. The '*Imbatto,*' or alternate land and sea breeze, blows from the sea between the forenoon and afternoon; calm succeeds at sunset; a breeze from the land follows from evening during the night, and calm prevails again at sunrise. This is the normal wind of all the larger islands of the Mediterranean as Cyprus, Candia, Sicily, Sardinia, and Corsica, and of most coasts, during the summer months.

Typhoons and Waterspouts.

The Mediterranean being thus the meeting place of such opposite winds, it is not surprising to find occasional whirlwinds and typhoons raising vertical columns of sand in the deserts of North Africa, and waterspouts in the sea. The '*Marobia*' (mare ubbriaco) is a phenomenon supposed to be caused by the meeting of a west and south-east wind sometimes experienced near the south coasts of Sicily. The water rises to the extent of two feet above its usual limit, and rushes into and out of the creeks with amazing rapidity. It is considered the certain precursor of a storm.

Products.

The *Tunny* fishery is an important source of commerce in the Mediterranean. This fish enters the sea in spring, and keeping along the European shores, passes to the Black Sea and Sea of Azov, to spawn, returning to the ocean by the African coast. The tunny fishery is prosecuted chiefly on the coasts of South France, eastern Spain, Sicily, and South Italy, and in the Black Sea about Constantinople. The *sword-fish* pursuing the shoals of tunny, is taken by harpooning. The '*Anchovy*' fishery is carried on chiefly at the island of Gorgona, between Corsica and Italy, the fish being caught at night, attracted to the boats by fires. The lagoon of Commachio, in the Gulf of Venice, is famous for its *eels*, which are sent to all parts of Italy.

Sponge is a valuable product of the archipelago. Diving for it is the sole employment of the inhabitants of the Island of Symia near Rhodes. *Coral* is procured around the Lipari Islands, in the Straits of Messina, and on the coasts of Corsica, Southern France, and Northern Africa.

Tides.

The phenomenon of tide is scarcely known in the Mediterranean. The effect of that which occurs in the Atlantic is felt only as far as to the east of Malaga, but long prevailing winds from any direction cause a heaping up of the waters in some parts, which may amount to several feet.

Earthquakes and Volcanoes.

The whole area of the Mediterranean basin is more or less subject to earthquakes, and contains two of the best known active volcanoes in the world, *Vesuvius* and *Etna*. The group of the *Lipari Islands* is entirely volcanic. The most remarkable of its islands are *Stromboli* and *Vulcano*, the former of which, from its unceasing eruptions, has been called the lighthouse of the Mediterranean. On the opposite side of the Island of Sicily, a very remarkable volcanic outbreak occurred in the year 1831, when an active cone appeared about 31 miles from the coast, and formed the island then called *Graham's Island*, which existed from July to October of that year, and was 200 feet in height, and three miles in circumference at its greatest. In the Ægean Sea, the Island of *Santorin* or *Thera*, is of volcanic origin; in January 1866, a new cone was erupted in the centre of the sea basin, which the island nearly surrounds.[1]

The following Tables give the *Area and Drainage* of the various parts of the Mediterranean system, the length and area drained by its chief rivers, and a comparison of their basins with that of the Thames.

	Sq. Miles.
Area of the Mediterranean and Sea of Marmora (Smyth),	976,781
" Black Sea and Sea of Azov, . (")	172,506
[2] European Drainage to Mediterranean, . . .	363,000
" " Black Sea, ...	825,000
Asiatic Drainage to Mediterranean, ...	98,000
" " Black Sea, ...	114,000
African Drainage to Mediterranean (Nile and N. Coasts). .	1,386,500
Drainage to Mediterranean, .	1,847,500
" Black Sea, .	939,000
Drainage to Mediterranean and Black Sea, . .	2,786,500
Area of Mediterranean and Black Seas, . . .	1,149,287
Total area of System of Mediterranean,[3] . .	3,935,787

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[1] An enlargement of the volcanic district of Etna and the Lipari is given at the foot of the map.

[2] These figures, and those for the rivers which follow, are from original measurements from the largest scale maps.

[3] The diagram in the left corner of the map shows the whole area of the Mediterranean system.

	Chief Rivers of the Mediterranean System.	*Length.*	*Area of basin in Sq. Miles.*	*Thames = 1.*
In AFRICA, . .	Nile (including L. Tanganyika) to Lucenda, Sheliff (Algeria), .	5800 320	1,290,000 15,700	250 3
In ASIA, ...	Kizil Irmak, . .	580	29,900	5·8
In EUROPE to Black Sea, . . .	Don, ... Dnieper, . . . Bug, ... Dniester, ... Danube, ...	1000 1050 410 660 1560	176,500 195,500 25,800 27,300 306,100	34 38 5 5·3 59
To Mediterranean,	Maritza, ... Po, ... Rhone, . . Ebro, ...	260 360 420 380	18,200 34 600 37,900 32,900	3·5 6·7 7·[illegible] 6·3

The isothermal lines[1] shown on the map give the mean temperatures of the months of January and July. It is observed that the temperature of the greater part of the Mediterranean in July is between 70° on the European side, and 80° in North Africa; but that there are several isolated areas with a greater temperature between these two lines, as in Eastern Spain, the plain of North Italy, and the eastern parts of Sicily, Turkey, and Greece. In January, the temperature of the north coasts of the Mediterranean is 40°, and of the south coasts 55°, but the Black Sea lies between the lines of 30° and 40° Fahr.

Climate.

From these lines the winter and summer temperatures of any desired place may at once be determined, by observing the January and July lines between which it lies.

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[1] These lines have been drawn originally for this Map from the reduced observations at a large number of stations in Europe, Algeria, and in Asia Minor and Syria, most of them supplied by the kindness of Mr Buchan, Secretary of the Scottish Meteorological Society, for this purpose.

HYDROGRAPHIC MAP OF THE BRITISH ISLES.

MAPS 19 and 20.

THE first step to a complete understanding of the physical features of any country, is a knowledge of its River Systems, since the rivers are the natural highways of the land. The main streams mark, with unfailing accuracy, the greater natural openings into the country; their tributaries define the valleys, and the feeders of these tributaries, the lesser hollows and depressions of the higher land; whilst the sources of those which flow towards opposite seas, point to the line of the most generally elevated land, the back bone of the country.

The courses of rivers are determined by the form of the land, since water invariably seeks the lowest level; and their strength or volume by the distance of their source from the sea, by the amount of rainfall in the area through which they flow, the number of tributaries they receive, or by the rapidity or gentleness of their descent.

The main stream of a river begins at the source which is farthest removed from the sea, in the direction of the winding of the river which proceeds from it. The *source* of a main stream, or the point at which it begins to have the power of flowing, is always at a higher relative level than the course of the stream, and occurs at the place where water, deposited in the form of rain on the high ground, turns to flow to one descent or the other, on each side of a balance point of rest. A line joining the source of a river, with the sources of its tributary streams, is the *water-parting*, which marks out the limits of the *basin* of the stream; and the slope from all sides down which the tributary streams flow to the central channel of the river, is the *watershed* of the basin. The water-parting is thus always a double boundary, being at the same time a part of the waterparting of the river basins which lie on each side of the central one. Each tributary stream has a sub-basin, the length of which is measured by the distance from the source of the stream to its confluence with the main river; and this sub-basin has a minor water-parting, which again includes the basins of the feeders of the tributary, and these may be sub-divided to the hollow of the last single rill, so that the basin of each river which reaches the sea, is an agglomeration of a multitude of minor divisions.

River basins which drain to the same sea, or in the same general direction, are classed together to form a *river system.* These systems are divided by the water-parting line which lies at the sources of the rivers which flow to opposite seas, called the *main water-parting* of the country, to distinguish it from the minor water-partings of the river basins.

This main water-parting may, but does not necessarily follow the direction of a central range of mountains, or even the absolutely highest ground, since the sources of tributary streams may be higher than the source of the main river, but still it must maintain the direction of the most generally elevated land.

Minor Systems of the British Isles.

The British Isles form a small part of the Atlantic proper system of European drainage;[1] but for the right comprehension of the hydrography of the islands, a sub-division into minor systems, according to the main water-parting lines, is necessary. The most natural sub-division seems to be that of the drainage to the cardinal points of the compass, which gives to Britain a drainage to the east to the North Sea, to the south to the English Channel, and west and north to the Atlantic; whilst Ireland has a northern, western, and southern drainage to the ocean, and an eastern flow to the Irish Sea.

Main Water Partings.

In the contour map of the British Isles, which precedes this one in the Atlas, we have seen that the higher land lies invariably to the western side of the island of Great Britain, and in a circle round the coasts of Ireland. From the elongated form of the island of Great Britain in the direction from north to south, it follows that the line which separates the westward from the eastward flowing waters is the greatest; and this line, following the direction of the most generally elevated land, lies uniformly nearer to the western than the eastern side; the northern and southern water-partings, which branch off from the ends of the central line, are comparatively very short. In Ireland the main water-parting lines meet more nearly in the centre of the island, but the longest is that which runs from north-west to south-west in a curve, which approaches the eastern coast, and marks off the greatest drainage area of Ireland to the *west*, instead of to the east, as in Great Britain. The remainder of Ireland is shared more equally between the three smaller systems.

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[1] See Map 21.

The following table gives the areas of the different systems of the British Isles, and shows that more than one-half of the extent of Great Britain is drained to the eastward, and nearly one-half of Ireland to westward; whilst the southern system of England is very small, being only one-fourth of the extent of the eastern, and one-third of that of the western system of Britain; and that the least of all is that of the north of Scotland, whose area is only one fortieth part of that of the greatest,—the Eastern System of Britain.

AREAS OF THE RIVER SYSTEMS IN SQUARE MILES.

	Northern.	*Southern.*	*Western*	*Eastern.*
England, ...	...	7,306	21,255	29,759
Scotland (Mainland), . .	1,120	...	10,337	15,356
Great Britain, . . .	1,120	7,306	31,592	45,115
Ireland, ...	4,800	6,800	15,750	5,150
British Isles, ...	5,920	14,106	47,342	50,265

The Eastern System of Britain extends from Duncansby Head on the north-east, to near Dover on the south-east, and includes most of the larger rivers. Nearly a sixth part of its area is occupied by the basin of the largest river of Britain,—the Thames.

The Western System extends from Cape Wrath to Lands End; the Southern from Lands End to Dover; and the Northern from Duncansby Head to Cape Wrath.

The Eastern System numbers twenty-five rivers, each of the basins of which has an area of more than 400 square miles, the minimum area of those river basins whose extent is given on the Map; the Western System sixteen of these, the Southern only four; whilst the Northern System has no rivers, properly so called, the basin of its largest stream being only 200 square miles in extent. In Ireland the Western System extends from Mizen Head on the south-west, to Bloody Foreland on the north-west; the Northern System from that to Fair Head on the north-east; the Eastern between Fair Head and Carnsore Point, at the south-east corner of the country; and the Southern from Carnsore to Mizen Head. More than one quarter of the extent of the Western Drainage System of Ireland is occupied by the basin of its largest river, the Shannon; but there are four others, whose basin exceeds 400 square miles in area. In the Northern System there are but two, whose basins are of this extent; in the Eastern System three, and in the Southern also three.[1]

Lakes of the British Isles.

The lakes of the British Isles are curiously distributed, being almost exclusively confined to North Britain and north-western Ireland. The lakes of Scotland and of the Cumbrian Mountains of north-western England, are generally of the same character, being formed in the depression of a glen or valley between high mountains or hills, with even, deep sinking shores, and they are usually at a considerable elevation, some reaching as high as 2000 feet above the sea. The two largest lakes of Scotland, which lie close to the coast, are exceptions to this general rule of elevation, the surface of Loch Lomond being only 23 feet, and Loch Ness 53 feet above the sea, but Loch Tay is 383 feet, and Loch Ericht, in the centre of the country, 1149 feet above the sea. In the Cumbrian mountains Winder Mere is 134 feet; Ulleswater, 476 feet; Derwent Water, 238 feet; and Bassenthwaite Lake, 225 feet; but some of the smaller tarns are at an elevation of above 2000 feet. In contrast to those of Scotland, the lakes of Ireland are generally mere expansions of the larger rivers, in a flat boggy country, with shallow and marshy edges, not surrounded by any eminences, and at no great elevation. Lough Neagh, the greatest in extent in the British Isles, covers an area of 154 square miles, and is only 48 feet above the sea, though at a considerable distance from it. Upper Lough Erne is 151 feet, and the Lower, 149 feet above sea. The great lakes of the Shannon basin, Loughs Allen, Ree, and Derg, are respectively, 161, 125, and 110 feet above the sea; and the lakes of Galway only 30 feet. The lakes of Killarney, 68 feet above sea, at the base of the highest mountain range of Ireland, form an exception to the general character of Irish lakes. The highest lake in the country is perhaps that at the head of the Brosna, near the water-parting between the Shannon and the Boyne, 327 feet above the sea.

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[1] The lengths of the rivers, and areas of the river basins of Scotland and Ireland, given in this map, are the results of a careful series of original measurements from large scale maps; those for England have been taken from the 'Plan of the Catchment Basins of the Rivers of England and Wales,' published at the Ordnance Survey Office in 1861. The areas of the river systems are, it is believed, measured for the first time.

It is curious to observe that there are no lakes in the Eastern System of England south of the basin of the Tweed, in the Southern System, or in the Western, south of the Cumbrian Mountains, with the exception of the little Bala Lake, at the head of the River Dee, in Wales; and there are no lakes of importance in the Eastern or Southern Systems of Ireland, excepting Lough Ramor, at the head of the Blackwater, which is only 4 miles in length by 1 mile in average breadth.

Fall of the Rivers.

The *fall* of a river is the amount of its descent over the land from its source to the sea, and this descent is naturally proportioned to the steepness or flatness of the ground which it traverses. The diagram at the foot of the Map gives an exaggerated idea of the descent of three of the larger rivers of the British Isles. The Tay, in the highlands of Scotland, has a rapid descent throughout its course from an elevated source; the Shannon flows nearly at a level during the whole of its middle course over the plain of Ireland, only increasing in its fall and rapidity at its extremities; and the Thames has an even and more gentle descent throughout its length. The Contoured Map of the British Isles, on the same scale as this Map, gives an idea of the fall of the other rivers, by showing the approximate elevation of their sources and the number of different heights through which they pass on their way to the sea; the part of the river's course which lies between closely approaching contour lines is sure to be rapid; and again, between widely distant contours, we may expect a sluggish stream.

Navigable Rivers.

Owing to the rapidity of their descent to the sea, there are no navigable rivers in Britain north of the lowlands of Scotland; but in the plains of South Britain the natural navigation reaches far into the interior of the country. The whole of England to the west of a line drawn from Newcastle-on-Tyne to above Oxford, on the Thames, is supplied with natural highways in its navigable rivers. In the central parts of the Southern System the rivers are navigable for a general distance of half their length from the sea, but farther west the highland character of the peninsula between the Bristol and English Channels, prevents the possibility of natural navigation. The Severn forms a high road, opening up a large tract of country between England and Wales. It is navigable to beyond the junction of the Vrnwy, in North Wales; and its tributary rivers, the Avon and Wye, are navigable for half their length. With the exception of the Teifi, which is navigable for about two-thirds of its course, there is no natural highway into Western Wales. The Mersey opens up the plain of Cheshire; but beyond this to the northward, with the exception of the Clyde, there is no navigable river in the Western System of Scotland.

In Ireland the country to the east of a line from Dublin to Cork, is penetrated by navigable rivers; but the higher land on the south-west, between Cork and the Shannon, is closed against natural traffic. The Shannon opens a way into the whole central plain of Ireland, being navigable to Lough Allen, almost throughout its entire course.

Beyond the Shannon the rivers of the west and north-west coasts are practically innavigable; but on the north, the Foyle is navigable for about one-third of its length from the sea, and the Bann, with its tributaries above Lough Neagh, opens up the northern plain of Ireland. The country on the east is again closed till we arrive at the Boyne and Liffey, which are navigable for a short distance.

The following is a list of the rivers of the British Isles which drain a greater extent than 1000 square miles, arranged in the order of the size of their basins, with the length and navigability of each :—

	Area of Basin in sq. miles.	*Length.*	*Navigable above Estuary.*	*Miles.*
Thames,	5162	201	To Lechlade,	160
Shannon,	4590	160	,, Lough Allen,	146
Severn,	4437	178	,, Welshpool,	120
Ouse,	4207	130	,, Ripon-on-Ure,	70
Trent,	3972	167	,, Burton,	105
Barrow,	3517	105	,, Athy,	70
Great Ouse,	2894	156	,, Bedford,	90
Bann,	2265	95	,, Newry Canal,	55
Tay,	2090	90	,, Perth,	8
Tweed,	1990	96	,, above Berwick,	6
Mersey,	1706	68	,, Junction of Irwell,	25
Erne,	1660	90	,, Ballyshannon,	2

	Area of Basin in sq. miles.	*Length.*	*Navigable above Estuary.*	*Miles.*
Wye,	1655	148	To Hay,	100
Blackwater,	1300	80	„ Lismore,	22
Spey,[1]	1245	95	„ Cong,	25
Humber,	1229	37	Throughout.	37
Galway,	1172	65	Innavigable?	
Clyde,	1145	90	„ Glasgow,	12
Foyle,	1090	52	„ Strabane,	20
Nen,	1055	99	„ Northampton,	85
Tyne,	1053	35	„ Ryton,	25
Witham,	1052	89	„ Lincoln,	40
Boyne,	1046	63	„ Navan,	19

Canals.

Numerous canals aid navigation in the British Isles. The most northerly of these is the Caledonian Canal, which unites the North Sea with the Atlantic, through the chain of lakes of the Great Glen of Scotland. Further south in the lowlands a canal unites the estuaries of the Forth and Clyde. Several canals cross the main water-parting, to connect the tributaries of the Ouse and Trent with the Mersey and the Dee in the north, and the Severn in the south, to facilitate the operations of the manufacturing districts of Central England. Two canals join Central England with the Thames and the metropolis, and two unite the Thames with different parts of the Severn, one by the Lower Avon. A canal joins the middle course of the Thames with the River Arun on south coast, and the south-western peninsula of England is twice crossed—once by a canal between the Parret and the Exe, and again from the Tamar to the west coast. Communication is effected across central Ireland by two canals from Dublin to different parts of the Shannon in the west, and by a canal to the Barrow, for the south. In the north of Ireland a canal joins Lough Neagh and the River Erne, and another connects Lough Neagh with Carlingford Lough on the east coast.

Tides.

The great tidal wave from the Atlantic approaches the British Isles from the south-west. It first reaches the south-west peninsula of England and the extremity of Ireland at Cape Clear Island, and carries high water along the south coast of England and the north coasts of France; a portion follows up the Bristol Channel, and part up the Irish Sea. At the North Channel, this wave meets another part of the same wave, which has advanced from the north round the outside of Ireland to the west coast of Scotland, and which, afterwards entering the North

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[1] The most rapid river of Britain.

Sea, turns southward, and meets the tidal wave which followed the first, twelve hours later, from south-west, in the Strait of Dover; thus causing the troubled sea for which these two channels are notorious. The rise and fall of spring tides varies from ten to as much as thirty feet in different parts of the coast, and is uniformly greater in those parts where, from the gradually shelving nature of the sea-bed, the tidal wave, advancing through the entire depth of the ocean, is forced gradually upwards by the wedge-shaped surface over which it moves. Such a formation of the sea-bed in a gradually narrowing estuary causes the phenomenon known as the '*bore*,' when during spring tides, after a low ebb, the tidal wave advances up the sloping and narrowing passage with great rapidity. This phenomenon is specially noticed in the Solway Firth, where the meeting of the tidal waves from the south and from the north may aid the flood, and also in the Bristol Channel, where the spring tides rise very high, and the 'bore' rushes into the Severn with great violence, causing the river sometimes to rise suddenly as much as nine feet at Gloucester.

THE RIVER SYSTEMS OF EUROPE.[1]

MAP 21.

No part of the world is so admirably adapted by nature for attaining a high civilization as the continent of Europe. Placed in the centre of the habitable globe, in a temperate region, where neither the fierce heat of the sun, nor the rigorous frost, can prevent the constant activity of its inhabitants, Europe has natural outlets on every side for communication with the whole world in the seas which surround it, and ready-made highways to these seas from the interior of the land, in its navigable rivers. On the west, the Atlantic Ocean is the great bridge of its commerce with the New World; the Baltic Sea and its arms open a way for ships into the north of the continent; the Mediterranean and Black Seas form a highway of traffic, as well between Eastern and Western Europe, as between these and the continents of Africa and Asia; and only on the east, where Europe is united to Asia, is its traffic carried on overland, by slow and toilsome caravans. The western coasts of Europe, washed by the Atlantic, are well supplied with natural harbours, either sheltered behind the islands which line the higher parts of the coast, or in the estuaries of the greater rivers which occur on the lower shores; and the ocean tides entering these estuaries, and penetrating far up the river course, greatly aid their traffic in producing an alternate current.

The Baltic is a shallow and tideless sea; its waters are fresher than those of the Atlantic, and it may be considered as a great expanded estuary of the rivers of Northern Europe, having a constant outward current.

Its coasts, opposite some of the more productive parts of the countries surrounding it, are so shallow, that the harbours do not admit of large vessels; and yearly, from December till April, the navigation is prevented by the ice which then surrounds its shores, and blocks up the harbours and rivers. On the side next Europe, the Mediterranean coasts seem specially designed to afford shelter to vessels, in the numerous gulfs and bays and inner branches, which lead into every part of the south of the continent, contrasting in this respect with the inhospitable African shores.

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[1] To preserve a relation between the scale of this map and the general maps of the quarters of the globe, a scale has been adopted which gives this map double their area, or a square of 10° on the central meridian of this map is double the area of a square of 10° on the central meridian of the general maps.

Europe drains to two Oceans and a Continental System.

The great river systems of the world[1] have been classed according to the oceans to which the rivers flow. In this view, the rivers of the continent of Europe form a small part of the systems of two oceans, the Arctic and Atlantic, whilst a third part, in the east of the continent, belongs to the great continental system of Asia, from which no water escapes directly to the sea, but is drawn up from the inland lakes and seas to which the rivers flow, by an evaporation, which must be exactly proportioned to the amount of water brought down by those rivers, since the extent of the lakes remains the same. Only a seventh part of the area of Europe, in the north of Norway and Russia, is drained to the Arctic Ocean; but this is the most useful part of the whole of the arctic system of the world, since, owing to the peculiarity of the climate of Western Europe,[2] the White Sea is often free from ice for nearly six months of the year, and the River Dwina, which falls into it, is navigable throughout its entire course, and is connected by canals to the Neva and Volga, with the Baltic Sea, and with the whole of Central Russia to the Caspian.

Atlantic proper drainage.

West of a line drawn from near the north of Norway to between the Black and Caspian Seas, the whole of Europe drains to the Atlantic, either directly to the ocean, or to one of its Mediterranean branches. Nearly a third part of this area, the outer westerly slope of the continent, embracing a great part of the Spanish peninsula, the plain of France, a part of the European plain in the Netherlands and in Western Prussia, and half of the Scandinavian peninsula, besides the British Isles and Iceland, drain directly to the Atlantic. The lower middle part of this Atlantic slope, and the islands opposite it, is the central area of the active industry of the world, the natural advantages of its rivers have everywhere been improved by artificial means, and their branches have been united by canals to form a complete network of water communication. The northern and southern parts of this system are, from the high nature of the land, of less practical utility.

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[1] Maps 15 and 16.

[2] See Maps 23, 24, and Notes.

Basin of the Baltic.

Another part of the Atlantic system in Europe is the basin of the Baltic Sea, which contains the lake region of the European plain. In the northern parts of this basin the rivers are unfit for navigation, though they are made use of in Sweden for floating down the timber from the forests of the higher country; but on the east and south, all the larger rivers are navigable. The Neva, on the east, continues the navigation of the Gulf of Finland through the great lakes of Ladoga and Onega, and is connected by canal with the Volga; and the Niemen, on the south, unites the Baltic with the Black Sea by a canal to the River Dnieper.

Basin of the Black Sea.

A second interior division of the Atlantic system in the basin of the Black Sea, lies partly in the higher region of Southern Europe, and partly in the European plain. The higher part of this basin is exclusively drained by the River Danube and its tributaries; the plain in South Russia chiefly by the Rivers Dnieper and Don. A canal joins the head waters of the Danube with the Rhine and with the Elbe, and by this means a great highway is formed across the centre of this part of Europe, from the north to the Black Sea; the Dnieper and the Don and their tributaries also open up a great part of the plain of Russia.

Mediterranean drainage.

We have seen[1] that this line of greatest general height in Europe passes close to its southern shores, and for this reason the drainage to the Mediterranean—that of the steeper slope of the mountains—occupies but a small part of the Atlantic system, and the rivers forming it are naturally short. The greatest of these, the Rhone, is also the most useful to the industrial country through which it passes, and is united by canals to all the other large rivers of the plain of France, and to the Rhine on the north.

The basin of the River Volga occupies nearly the whole extent of the continental drainage of Europe. Its head waters reach those flowing to the Arctic Ocean on the north, and branching out over the greater part of the plain of Russia, complete its net-work of rivers. All of its tributaries are navigable nearly to their sources, so that there is no part of the great plain of Russia without its natural highway, and from its main course the navigation is continued through the Caspian, to the barrier of the plateau of Persia on its southern coasts.

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[1] Map 5.

Continental drainage.

A vessel might thus pass by water back and forwards across the continent of Europe: entering the Loire, in the plain of France, it could be navigated to the Rhone, thence to the Rhine, from that to the Danube, and down that river to the Black Sea; from the Black Sea a passage might be made by the River Dnieper to the Niemen, and thence to the Baltic; then entering the Neva, and passing through the great lakes into the Volga, the voyage would be completed by turning north through the Dwina to the White Sea, or southward to the Caspian.

The surface temperature of the sea, as a general rule, follows that of the land, though more slowly, and is found to be greatest in the tropical regions, decreasing towards the poles. Off the coasts of Europe the temperature of the surface of the sea varies from a high degree of warmth in the south, to near the freezing point in the north. In the latitude of the south of the peninsula of Spain, the spring temperature of the sea is 60°, and in autumn rises to 70°.[1] In the latitude of the south of the British Isles these temperatures fall to 50° and 60° respectively; but to north of this, the sea temperatures in the great gulf, between Greenland and the European coasts, are thrown out of their regular order by the remarkable conditions of the temperature of this part of the world, and decrease rather to westward than to the north. In summer, the temperature of the surface of the sea off the north coasts of Norway is 50° Fahr.; of the centre of the channel, 40° Fahr.; whilst on the opposite coasts, next Eastern Greenland, the temperature is less than 32° Fahr., and this difference seems to be preserved throughout the year. The normal average limit of ice on the ocean, according to the more regular decrease of its surface temperature, would fall near the Arctic circle (66½° N. latitude); but here we find this arrangement completely altered, and the average limit of ice carried far to the northward on the eastern side of the gulf, next the European coasts, and far beyond its normal limit to southward, on the coasts of Greenland.

The Ocean next Europe.

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[1] February and March, and August and September, from the 'Board of Trade Current Chart of the Atlantic,' 1869.

This phenomenon is partly explained by the existence of a drift current from the warmer regions of the Atlantic, constantly washing upon the European shores, and partly by the prevalence of the south-westerly winds, the 'Anti-Trades,'[1] which, while assisting the flow of this surface drift of warmer waters, bring with them the milder atmosphere of the tropics, which, perhaps, has a much greater effect in preventing the formation of ice than the drift water. Then, on the opposite shore, there is a constant stream of ice being carried to south-westward by a cold current, along the shores of Greenland, and round Cape Farewell into Davis Strait, but it seldom reaches as far east as Iceland, and never touches even the most northerly points of Norway in a higher latitude.

Icebergs and drift ice may be met with far to the south of Cape Farewell, and reach down, in the western Atlantic, near the American coasts, to the latitude of Spain; on the European side their furthest south limit is the Færoe Islands, and icebergs never approach the Norwegian coasts.

The area and elevation of the chief European lakes in the different divisions of the Atlantic System, are given in the following Table; there are no important lakes in the European parts of the Arctic or Continental Systems.

	Area in Sq. Miles.	*Height above Sea in Feet.*		*Area in Sq. Miles.*	*Height above Sea in Feet.*
Chief Lakes of **Atlantic Proper Division.**			Chief Lakes of **Black Sea Division.**		
L. Wener,	2020	114	Platten See,	380	455
L. Neuchatel,	91	1426	Neusiedler See,	160	367
L. of Lucerne,	40	1433			
L. of Zurich,	34	1341			
L. Constance,	183	1200	Chief Lakes of **Mediterranean Division.**		
Chief Lakes of **Baltic Division.**			L. of Geneva,	221	1230
L. Wetter,	710	290	Lago Maggiore,	80	687
L. Onega,	3380	237	L. di Como,	61	697
L. Ladoga,	7150	49	L. di Garda,	560	227
L. Peipus,	1410	95			

The following Table gives the areas of the different systems and divisions, as also the length, and the area of the basin, of the chief rivers in these, and a comparison of their drainage area with that of the Thames, taken as the unit of measure. The extent to which each is navigable is given in the last column in English miles.

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[1] Map 22.

Systems and Chief Rivers.	*Length in Miles.*	*Area of Basin in Sq. Miles.*	*Area compared with Thames = 1.*	*Navigable from Sea.*
European part of **Arctic System.** 570,000 sq. m.				
Petchora,	850	114,400	22	To 700 m. from mouth. Estuary open from June to September.
Mezen,	350	30,100	5·8	Almost to source.
N. Dwina,	790 Vitchegda. 730 Sukhona.	134,500	26	Throughout both tributaries. Connected with Neva and Volga by canals.
Onega,	350	21,000	4	To L. Latcha 240 m.; impeded by falls.
European part of **Atlantic System.**				
(1) *Atlantic proper division. 770,000 sq. m.*				
Glommen,	340	16,000	3	Navigation impeded by falls.
Gotha, with L. Wener,	400	17,000	3·3	By locks to L. Wener, 55 miles.
Elbe,	630	55,000	10·6	To confluence of Moldau, 420 m.
Weser,	330	17,700	3·4	Partially throughout.
Rhine,	700	75,000	14·5	For sea going vessels to Cologne, and for steamers continuously to Basle, 500 m
Thames,	200	5162	1	To Lechlade, 130 m.
Seine,	410	28,500	5·5	To Troyes, 370 m.
Loire,	520	44,500	8·6	To Roanne, 430 m.
Garonne,	330	31,000	6	To Cazères, 260 m.; connected by Canal du Midi with Mediterranean.
Duero,	410	34,200	6·6	To Saò Joaô de Pesqueira, 80 m.
Tagus,	500	33,000	6·4	To Abrantes, 90 m.
Guadiana,	430	25,000	4·8	To 35 m. from mouth.
Guadalquivir,	300	19,500	3·8	To Cordova, 160 m.
(2) *Baltic division. 717,000 sq. m.*				
Neva, with Ls Ladoga and Onega,	420	99,700	19·3	To Weliki-Luki, on Lovat, 370 m.; connected by canal with Volga.
Narova and L. Peipus,	290	19,600	3·8	To Pskov, at head of L. Peipus.
Dwina,	520	34,700	6·7	To Velij, 405 m.
Niemen,	470	35,700	7	To within 30 m. of source; connected with Dnieper by canal.
Vistula,	520	72,300	14	To Cracow, 430 m.
Oder,	480	45,200	8·9	To beyond Ratibor, 420 m.
(3) *Black Sea division. 825,000 sq. m.*				
Don,	1000	176,500	34	To Donkov, 840 m.
Dnieper,	1050	195,500	38	To Dorogbush, 990 m.
Bug,	410	25,800	5	To Vosnesensk, 85 m.
Dniester,	660	27,300	5·3	To Halicz, 560 m.; interrupted by falls.
Danube,	1560	306,100	59	To Ulm, 1450 m.; communicating by canals with Rhine and Elbe.
(4) *Mediterranean division. 363,000 sq. m.*				
Maritza,	260	18,200	3·5	To Adrianople, 80 m.
Po,	360	34,600	6·7	To Casale, 240 m.
Rhone,	420	37,900	7·3	To Seyssel, 260 m.
Ebro,	380	32,900	6.3	To Tudela, 210 miles by canalization.
European part of **Continental System.** 689,000 *sq. m.*				
Volga,	1920	527.500	102	Throughout; for steamers to Tver, 90 m. from source; connected by canals with Baltic.
Ural,	900	85,000	16·4	To Orskaja, 680 m.

Meteorology.

WINDS AND STORMS.

MAP 22.

Trade Winds.

OUR earth is enveloped by a great universal ocean of air called the atmosphere, the lowest part of which rests upon the surface of the land and water. The parts of the atmosphere lying next to the earth's surface are found to be much more dense than those above, being compressed by their weight, and this density decreases rapidly as we ascend, till at a height of perhaps fifty miles above the earth, it is supposed that we should arrive at the surface of the atmosphere.[1] The depth of this vast ocean is found to be greater, by its exerting a generally greater pressure on the instrument which has been devised for measuring its change of weight, the barometer, in the equatorial regions than in those lying nearer the poles; but this pressure varies greatly in the tropical and temperate regions of the globe, the lower pressure generally following the vertical sun and leaving the higher pressure in the opposite hemisphere. The most equal distribution of the atmospheric pressure occurs after the equator has passed beneath the sun, in April and in October.[2] As the earth revolves, those parts of its surface and atmosphere between the tropics which pass directly under the sun become greatly heated; this heat causes an expansion of the bulk of this part of the air, and a consequent diminution of its weight. Becoming thus lighter this air ascends, and would leave a vacuum behind it if the space were not immediately filled up by the air on each side of the ascending column, over which there is a greater weight of cooler atmosphere, rushing in to supply the deficiency. This is the cause of the constant winds called the '*trade winds.*' If the globe were at rest, and there were no land on its surface, or perhaps if all were land and no water, then we should have from this cause a constant flow of the air towards the equator in a due north and south direction. The speed of the rotation of the earth from west to east, at the latitudes north and south of the equator, where the trade winds begin to be drawn into the central area, is less than it is in the equatorial regions to which the wind is travelling; so that at first this double movement, the equatorward flow of the wind and the eastward rotation of the earth below it, gives to the trade wind a motion between these, or from north-east in the northern and from south-east in the southern hemisphere, and this easting increases as the rapidity of the rotation within the tropics becomes greater. If the foregoing condition of a uniform surface existed, these winds would be observed to form a complete girdle round the globe; but as it is, where the lands intervene to separate the seas, we find that the trade winds are interrupted—the land surface causing a different arrangement of the atmospheric pressure; and it is observed that the south-east trade winds are more uniform in direction throughout the year, and stronger than the north-east, since the surface of the southern hemisphere is less broken up by land than the northern. In passing over the oceans the trade winds draw up great quantities of vapour; and this moisture rising in the equatorial ascending current, condenses in the upper region of the air, thus giving an additional impetus to the inflowing current, whilst producing the almost constant tropical rains. The easting of the trade winds in the equatorial regions of the Atlantic seems to be increased by their rushing to fill up the vacuum produced by the condensation of the moist air drawn across the ocean on its meeting the high barrier of the Andes mountains. The average speed of vessels in the south-east trade wind in the Atlantic is from 5 to 6 miles[1] an hour, the strength of the wind being greater nearer the equator.

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[1] Observations of the end of twilight, that is of the disappearance of the last trace of light from the circle, in the tropics (by Dr Behrmann, Petermann's Mittheilungen 1868), give an elevation for the light reflecting part of the atmosphere of about 37 English miles; the elevation at which meteors ignite, indicates, on the other hand, a height of perhaps 150 miles, for the more ethereal part of the air. It is probable that only the lower and denser strata of the atmosphere are affected by the movements of winds and storms.

[2] Buchan's charts, showing the mean pressure of the atmosphere for the month and for the year. *Transactions of the Royal Society of Edinburgh*, vol. xxv

The air carried upwards at the equatorial region must turn back as an upper current to supply the same amount of air as that which is blowing towards the equator, to the atmosphere at another point. This return current, when cooled down in the upper regions seems to descend again to the bottom of the atmosphere, showing itself on the earth's surface as the prevailing westerly winds or '*anti-trades*' of the northern and southern temperate zones. These westerly winds arriving at regions near the poles, over which there is a less pressure, seem to rise again towards the surface of the atmospheric ocean, and to return in an opposite direction in the upper air to re-descend and supply the trade winds.

Anti-trades.

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[1] Maury, 'Physical Geography of the Sea.'

Equatorial Calms.

At the meeting line of the trade winds in the equatorial regions, a belt of calms is observed, called the region of Equatorial Calms, the '*Doldrums*' of nautical men, in which occur deluges of rain. From this cause the Equatorial Calm region of the Atlantic has received also the name of '*The Rains*,' which are accompanied by terrible thunder and lightning; waterspouts are also frequent. These calm areas have more properly a V shape, the broader part of the space being next to the western coasts of the continents where the winds blow more directly against each other, narrowing thence to the westward, where the winds having met, take an easterly[1] direction together; and they appear to move north and south within a space of about 20° of latitude during the year, since, whilst the part of the tropics in the northern hemisphere is under the sun, the south-east trade wind reaches a higher latitude, and whilst the southern hemisphere is more under the sun, the north-east trade blows further to the south.

Calms of Cancer and Capricorn.

Between the beginning of the westerly winds and that of the trade winds, just to the north and south of the tropics, in both hemispheres, there is a second zone of calms, accompanied by variable winds, called the Calms of Cancer and Capricorn. The '*Horse Latitudes*' of the Atlantic occur in this belt, between 25° and 29° of N. latitude, and are remarkable for continual change of winds, with sudden gusts and calms, rain, thunder, and lightning.

Polar Calms.

Again, in high latitudes, beyond the Arctic and Antartic Circle, in the Arctic regions of America and Siberia, are the regions of Polar Calms, though these are less definite than the preceding areas.

Such being the winds which maintain a more or less uniform direction throughout the year, and the calms between them, we next come to a class of winds which seem to follow the motions of the sun, or rather the oscillation of the earth under the sun.

When, by the inclination of its axis to the plane of its motion round the sun, the globe brings its northern hemisphere more directly under the sun's influence between the months of March and September, the land masses of Asia and North America become greatly heated. This heated surface causes an upward current of air, a low atmospheric pressure, and a consequent rushing in of the surrounding air to this part. Again, when the southern hemisphere turns more

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[1] The direction of a wind is always named after the point of the compass *from* which it blows.

Monsoon Winds.

Winds of Asia.

American Monsoons.

directly under the sun, a like pouring in of the winds takes place towards the low pressure thus caused in Africa and South America, in a reverse direction. Such are the periodical or '*Monsoon*' winds. These periodical winds have their greatest development in the upper part of the land-locked Indian Ocean and the China Seas, blowing from the south-east and south-west into Asia, whilst the northern tropic is under the sun from March to September, and from the north-east in the Indian Ocean, drawn in by the heated surface of Africa, and north-west through the influence of Australia towards that continent, during the time that the southern tropic is under the sun, from September to March. The continent of Asia, having the greatest surface exposed to the action of the sun, shows its influence most strikingly. The winds appear to blow out of Asia on all sides when the southern tropic is under the sun, when a high atmospheric pressure is observed increasing towards the centre of this continent; and the winds pour into it from all sides when it comes again under the sun, and when a low pressure of the atmosphere is observed decreasing towards the centre of the continent. From this cause the winds all round the continent of Asia have a monsoon or seasonal character. The same general system is observable in the other continents of Australia, Africa, South and North America, though in a less marked manner, the winds always flowing towards a low atmospheric pressure, caused by heat or moisture, and away from a high pressure caused by cold. Thus the winds are drawn into the region of South America, between the Equator and the Tropic of Capricorn, when this area is under the sun, from as far south as 40° of S. latitude in the west of that continent, and from perhaps the same latitude north of the Equator, in the west of North America, and further north in the centre of that continent; and out of it in exactly the opposite directions and to the same limits, into North America and to the south, when this region has been turned away from the sun, and North America is more directly under its influence. This is the cause of the American monsoons, which are most steadily experienced in the south, central, and western parts of North America, perhaps extending as far north as Hudson Bay, as well as in the western parts of Central and South America.

In the arctic regions of America the prevailing winds throughout the year are from north and north-west, with long intervals of calm. To the north of the 40th parallel in North America, on the east side

General Winds of America.

of the continent, the prevailing winds are westerly, being drawn into the anti-trades; they blow more from the north-west while the southern tropic is under the sun, and more south-west when the northern tropic has taken that position.

South America.

In the great plains of the Amazon in South America, and most towards the east coast, a continuation of the south-east trade wind prevails, especially in the dry season from March to September, taking an easterly direction, and is known as the '*vento general.*' On the west coast, between 15° S. latitude and the equator, a branch of the south-east trades, blowing directly from the south, is the prevailing wind. On the east coast, the trade winds from the east and south-east are felt, and south of them, in the neighbourhood of the Rio de la Plata, the variable winds called here '*virazones.*' To the south of the parallel of 30° S. latitude on the east, and below 40° S. on the west coast, the prevailing winds are westerly, taking a more south-west direction in the northern part of this area.

General Winds of Europe.

In the parts of Europe next the Atlantic, the westerly winds or 'anti-trades' prevail, the general direction being due west off the coast of France, in about latitude 50° N., more south-westerly to the north of this in the British Isles and the coasts of Norway and Denmark, and more north-westerly to the south of this, where a part of the under westerly current seems to be drawn round through the west of the Spanish peninsula into the north-easterly trade wind, descending from the upper regions of the air. In Eastern Europe the winds come under the influence of the Asiatic continent, and follow generally the periodical directions before described.

Peculiar Winds.

There is a class of winds which do not properly belong to either of the foregoing divisions of periodical or constant winds, and which are not generally experienced for a lengthened period at one season, but which have some peculiarity, either of heat or cold, of dryness or moisture, or of force, by which they are at once recognised on their recurrence, and from this peculiarity these winds have generally received a special name in the district in which they occur.

To this class belong most of the winds of the Mediterranean area, a description of which will be found in the notes to the special map of that region. The *hot winds* of Africa should perhaps be classed as periodical winds, from the regularity of their return at certain points at particular seasons. These hot winds seem to have a remarkable rotation round the north and west coasts of Africa during the year, always blowing directly out of the continent across the coast. The '*khamsin*' blows generally in Egypt from the end of April till June; the '*scirocco*' is felt most frequently on the Algerian coasts in July; in the interior of Eastern Marocco the '*shume*' or '*asshume*'[1] hot wind blows tempestuously in July, August, and September; further round, in the south-west of Marocco, on the Atlantic coasts, the '*shume*' blows with violence during 3, 7, 14, or 21 days in the beginning of September, and during its prevalence the ground becomes so hot as to burn the feet. In the middle of the west coast of Northern Africa, the '*harmattan*' begins to blow in November; and on the south-west coast, and in the Gulf of Guinea, sets in for from one to fourteen days at a time, from December to the middle of February. These different names all apply to this hot, dry, burning wind, which blows out of North Africa, always making its escape at one point or other of the coast at different seasons.

Hot winds, similar in character to those of Africa, are experienced on the coasts of Australia, blowing from the interior. These have been called the '*Australian Harmattan*.'[2] These winds blow from the north-west in South Eastern Australia, and in Victoria have a temperature of from 80° to 100° Fahr. As high a temperature as 120° has been observed there during the hot wind in February. In January this wind was experienced from the north, on the south coast of Australia. On the south-west coast it is observed to blow from the north-east; and on the north-west coast, in latitude 21° to 23° S., it was found to be from west and south-west.[3] This wind has been described as 'an oppressive and scorching current of heated air, like the hot blast of a furnace.' In South Eastern Australia it occurs on an average about four times every summer, and blows from 24 to 36 hours each time.

A remarkable wind, known as the '*Teploi veter*' (warm wind), is noticed by Wrangell. It occurs in the Kolyma district of Northern Siberia, and begins suddenly to blow from S.E. by S., raising the temperature in the middle of winter from −47° to + 35° Fahr., but seldom continuing longer than 24 hours.

In the western parts of the valley of the Mississippi, and in the Gulf of Mexico, cold dry winds, called '*Northers*,' or '*Los Nortes*,'

[1] Jackson's 'Marocco.'

[2] Lang's 'New South Wales.' 1852.

[3] Leichardt. 1846.

occur in winter. They are occasionally felt in September and October, but blow with much strength and continuance from November to February, decreasing again in March. These winds are also remarkable for the suddenness of their approach, and the rapid fall of temperature which they bring with them.

Strong breezes or gusts, termed '*Papagayos*,' from their blowing out of the gulf of that name, are experienced on the west coast of Central America between 10° and 13° N. latitude. These are the 'Atlantic trade winds, increased by induction through the pass formed by the Lake of Nicaragua and the neighbouring mountains.'[1] These gusts decrease about sunset, and attain their ordinary force about nine or ten in the morning.

In the '*Puna*' region of South America,[2] cold winds from west and south-west blow nearly all the year round from the ice-topped cordillera, and for the space of four months are daily accompanied by thunder, lightning, and snow-storms. These winds are described as sharp and biting, so keen that they cut the skin on the hands and face, and they have the remarkable power of speedily drying animal bodies, so that a dead mule is in a few days converted into a mummy. The temperature of these regions may vary as much as 40° Fahr. in the course of a few hours. Between the cold winds occur remarkable streams of warm air, sometimes only two or three paces, at other times several hundred feet broad, and the traveller may pass through five or six of these in the course of a few hours. These bands are observed to follow the direction of the cordillera from S.S.W. to N.N.E.; their temperature is 25° Fahr. higher than the adjacent atmosphere, and they are especially frequent in the months of August and September.[3]

The '*Pamperos*' are strong, dry, sudden south-west winds, which occur chiefly in July and August in the south-east of South America. They are a part of the 'anti-trade' winds which, blowing over the immense extent of dry pampas, are frequently accompanied by thunder storms and dense clouds of dust. Instances of their continuance for three days have been recorded, but they generally last only for a quarter of an hour. They are felt as far east as 48° W. long., and between the parallels of 31° and 41° S.

Equinoctial gales are the result of a temporary disturbance of the atmosphere, probably the result of the passage of the annual heat waves from one hemisphere to the other, with the differences of pressure which follow.

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[1] Sir E. Belcher. 1843.

[2] See the description of the Physical Map of South America.

[3] Von Tschudi; 'Travels in Peru.' 1847.

Direction of Surface Winds.

All land winds are more or less affected in character, and especially in local direction, by the nature of the ground over which they pass. Thus the wind flows through every valley in the direction of its length. If the valley lie in an east and west direction, all winds from north by west to south will be west winds in it, and all winds from north by east to south become easterly. Again, a mountain causes a double change in the direction of a surface wind, by causing it to flow round each side of the obstruction, and a range of mountains deflects the wind in the direction of the length of the chain. The same deflection is noticed when a wind which has been blowing in a uniform direction meets a cape or peninsula, and is bent round it in the form of the coast line. Very elevated places may have a completely different system of winds from those beneath them, so that observing stations in low uninterrupted plains only can be depended upon for giving the true course of a surface wind.

Whirlwinds.

Whirlwinds are caused by the friction of two winds moving in opposite directions, taking the direction of rotation from the wind which prevails, and are most frequent in the desert regions between the tropics during the hot season. They are of short duration, and the length of their course may be measured by single miles, and their breadth by yards. If they happen to originate over a sandy district, the finer sand or dust is carried up into the atmosphere with the revolving column. Such whirls reaching the sea suck up the water, so as to produce the phenomena of water spouts.

Hurricanes.

Hurricanes are vast whirlwinds, with a progressive motion of great velocity and destructive power, experienced in certain areas of the tropical regions of the globe, and in the parts of the temperate zones which lie next to these. The areas most frequently visited by these storms are indicated on the Map, and the general direction of the rotation of the hurricane is shown by a spiral line. Their general course is from east to west within the tropics, inclining towards the poles, and recurving to the north, or south, and eastward about the 25th and 30th parallels of latitude; and they revolve in opposite directions round a centre of low atmospheric pressure on the opposite sides of the equator, from right over to left in the Northern, and from left to right in the Southern Hemisphere. There is no recorded instance of a hurricane having crossed the equator from one hemisphere to the other, and under all circumstances they may be described as moving obliquely from their starting point towards the poles. These hurricanes take their rise very diversely 'wherever there happens to be a rapid concentration of vapour in the atmosphere;'[1] and such vacua seem to originate most frequently in the calm rain belts between the trade winds, or between the trade and an opposing monsoon wind. The hurricanes of the basin of the North Atlantic begin in the belt of the 'Doldrums,' or rains north of the equator, and pass in a curve north-westward towards and across the West Indies. The average turning point of these cyclones is off the coast of Florida, and here the course of the centre of the storm bends round to north and north-east, making towards the British Isles, but usually dying out before it has recrossed the ocean. The limits of their possible occurrence here are however very extended, the course of the storm sometimes stretching as far west as the Mexican coast. sometimes turning northward before reaching the 60th meridian of west longitude.

Typhoons.

The '*Typhoons*' of the China Sea and the Gulf of Bengal are analagous in their causes and nature to the hurricanes of the West Indies. They seem to be most frequent in the season of the south-west and south-east monsoons, and to be due to the meeting of these winds with the north-east trade. Typhoons have generally, but not invariably, a northerly progress.

Tropical hurricanes occur in the South Indian Ocean from November to May during the north-east monsoon. They originate between the parallels of 6° and 14° S. latitude, and thence proceed in a W.S.W. direction, and afterwards, though not always, their course curves round to south and south-east.[2] The direction of the whirl of the wind is here from left to right.

The progress of a hurricane, in its general direction, is comparatively slow. The general rate of the progress of the centre of the storms in the South Indian Ocean has been observed to be from 4 to 7 miles an hour, and that of the Bahama hurricane of October 1866[3] was only 15 miles until it had passed the Bahamas, and was nearing the Bermudas, when its speed was accelerated to 30 miles an hour; but this rate conveys no idea of the violence of the storm, which depends on the velocity of the rotation round and into the centre of the whirl, and had in this case a steady rate of from 80 to 100 miles, rising at intervals to 120 or 130 miles an hour.

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[1] Buchan.

[2] Meldrum.

[3] Buchan.

Extratropical Storms.

The general character of storms over the whole globe seems to be circular or elliptical, the atmosphere apparently 'flowing in upon a central area of low pressure in an inmoving spiral course;' and since, notwithstanding this constant inflow tending to increase the pressure, the pressure in the central area is not increased, Buchan concludes, that 'from a large area within and about the centre of the storm, a vast ascending current must arise into the upper regions of the atmosphere, and arriving there, must flow away over into the neighbouring regions.' The extent over which they spread is very variable. European storms seldom extend over less than 600 miles in breadth, and oftener two or three times that amount, the general direction of their course being from south-west to north-east, from the British Isles towards Norway and Denmark, dying out in the Baltic. Storms in Europe from north to south, or from west to south-east, are of rare occurrence.

Tornados.

Tornados are a species of hurricane which are experienced on the west coasts of Africa, between 10° S. and 20° N. latitude; occurring more or less frequently at all seasons of the year. A perfect calm prevails before the tornado; suddenly a small white motionless cloud appears in the highest part of the atmosphere; by degrees the air becomes agitated, and acquires a circular motion, the cloud increases in size, continues to spread out, and insensibly descends to the lower region of the atmosphere; at length it grows thick and obscure, and covers a great part of the horizon; by this time the whirlwind has increased, and the tornado becomes violent and terrible; the sea is wildly agitated, huts are swept away from the land, and trees blown up by the roots. These whirlwinds are happily of short duration. The storm lasts generally for only a quarter of an hour, and terminates in heavy rain.[1]

The chief authorities used in laying down the limits and directions of the winds in the map are, *for the sea*, the Board of Trade wind charts; and *for the land*, the observed direction of the winds, most of them for a considerable number of years, at 180 stations in different parts of the globe, collected and reduced by Mr Buchan, Secretary of the Meteorological Society of Scotland, and kindly lent by him for this purpose.

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[1] Golberry, in Purdy's 'Memoir on the Northern Atlantic Ocean.' 1845.

The projection which has been employed for this map is a new one, by the Rev. James Gall of Edinburgh, which, for certain purposes, has advantages over that of Mercator; and since this is the first published map in which this projection has been used, the following description of its properties may be acceptable:—

For a map of the world a cylindrical projection is by far the best, as it conserves better than any other, not only the relative positions, but also the geographical forms, of all the habitable portions of the earth. So much is this the case, that Mercator's chart, which is the only cylindrical projection hitherto adopted, with all its disadvantages, is almost universally in use.

There are three things in which a cylindrical map of the world may be perfect—these are: orientation, polar distance, and comparative area; but in order to secure one of these, the other must be sacrificed. The chart of Mercator sacrifices everything to orientation, and therefore to the navigator it is perfection, and cannot be improved. But in conserving orientation, Mercator has entirely sacrificed polar distance and comparative area, which, for every other purpose, are of much more importance. The equatorial and temperate regions, which constitute the whole habitable world, are compressed into a narrow strip in the centre; while the arctic and antarctic regions, which are neither large nor important, swell out into the most extraordinary forms and magnitudes, which waste the half of the paper. Thus, Greenland is shown with an apparent area equal to that of the continent of South America, or Alaska territory of the same bulk as Australia. As for the poles themselves, they reach upwards and downwards to infinity, so that the map can never be made complete, however extended.

The projection of the world by the Rev. James Gall remedies all this, by adopting the stereoscopic latitudes, and rectifying the longitudes at the forty-fifth degree Supplementary semicircles, above and below, unite and interpret the polar regions.[1] The advantages of this projection are as follow:—

1. There is a saving of 25 per cent. of space.
2. The comparative areas are better represented.
3. The *whole* world is represented in one map.

The following Table is a selection from the observations used in the construction of the Map, and are from the collection made by Mr Buchan. The places are arranged in each continent from west to east. The first column of the Table indicates the number of years in which the winds have been observed; the other columns give the average number of days in which the wind blew from a certain direction, or in which there were calms, during these years; and, further on, the peculiarities of the occurrence of these winds in the different months of the year at these various stations are noticed. At the end of the Table examples are given of a constant wind throughout the months, of a changing wind, blowing for half the year from one quarter, and for the other from the opposite; then of a wind prevailing from one direction, but not constant; and lastly, of a place with hardly any wind. These averages have been chosen as the most nearly perfect samples of these different winds which were obtainable; but even from these, it must be observed, that there is no absolutely constant wind from one direction only, or thoroughly periodical wind from two points in the year, since a place even in the heart of the strongest trade wind has several days of winds from other quarters.

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[1] Owing to the smallness of the scale of Map 22, these supplementary semicircles have been omitted.

EUROPE.	No. of years.	N.	N.E.	E.	S.E	S.	S.W.	W.	N.W.	Calms	Months in which a certain wind prevails.
Reykiavik, Iceland,	(9)	67*	44	62	37	27	52	13	29	34	N., in October and November.
Thorshaven (Farö Isles),	(—)	33	58	26	41	27	75*	55	30	13	N.E., in April and May.
Lisbon,	(8)	110*	95	35	6	18	19	44	21	17	N., March to September; N.E., October to January.
Oviedo, Spain,	(11)	57	114*	7	7	20	21	20	80	—	N.W., in Oct. and Nov.; N.E., June and Aug.
Gibraltar,	(6)	8	14	89*	4	15	60	43	95*	—	E., June to November; S.W., March to June W., July to September
Cork,	(11)	14	28	23	59	29	82*	40	90*	—	N.W., in July, 10 days; S.W., in Dec., 9 days.
Dublin,	(11)	21	18	44	31	26	88*	84*	31	24	
Stornoway (Hebrides),	(12)	25	28	39	27	42	87*	64	40	10	S.W., October to January.
Sandwick (Orkney),	(11)	26	21	23	78*	36	52	61	44	24	S.E., in May and August; N.W., in July; W., steady.
Aberdeen (Scotland),	(11)	28	23	15	40	41	112*	39	58	19	S.W., September to February; N.E., May.
Clifton, Bristol,	(10)	27	51	32	33	29	54*	70	50	19	W., in July, 10 days.
London (Greenwich),	(20)	41	49	23	21	34	103*	38	24	39	S.W., May to August, and in January; N.E., in April.
Paris,	(40)	38	42	25	28	54	69*	64	43	1	Steady.
Ahun, Central France,	(37)	36	73	25	15	35	96*	52	33	—	S.W., most September to November.
Brussels,	(40)	21	33	37	23	42	112*	67	31	—	
Emden,	(40)	30	33	59	32	40	79*	54	58	—	S.W., least April and May; E., Nov. to Jan.
Smidstrup, near Skagen, Denmark,	(7)	27	51	24	62	34	87*	53	26	—	N.E., in March; most S.W., June to Aug.
Bologna, Italy,	(45)	24	21	55	19	19	28	140*	60	—	W., least in May, June, July; E., April to Sept
Rome,	(11)	82*	49	40	12	76	44	48	11	(—)	S., April to Oct.; N., Oct. to May; S.W., April to August.
Malta,	(8)	25	57	29	38	19	51	30	106*	(—)	N.W., March to September; N.E., August to January; S., October and February.
Vienna, Austria,	(6)	53	9	9	56	49	18	38	133*	(—)	N.W., May to Sept.; S.E., Oct. to March.
Upsala, Sweden,	(8)	55*	57	29	19	48	49	34	37	(—)	N.E., May and June; S.W., Jan. and Feb.
Corfu, Ionian Islands,	(5)	65	42	67	71*	17	11	29	39	5	N., June to August; E., November to March.
Hammerfest, Norway,	(14)	30	16	39	71	76*	22	33	36	42	S. and S.E., September to March; Calms, May to September.
Lemberg, Galicia,	(5)	24	16	21	39	54	39	123*	47	2	W., in July; E., April to June.
St Petersburg,	(10)	24	29	24	37	36	51	75	29	60*	W., June and July; S.W., October to February; N.E., April to September; Calms, steady.
Kostroma, Russia,	(10)	35	15	33	52	71	44	77*	45	22	S.E., October to April; N.W., May to August.
Taganrog, Russia,	(16)	25	23	111*	28	30	21	49	23	42	E., September to April; W., June and July; S.W., May to Aug.; Calms, Oct. to Dec.
Novaia Zemlia,	(2½)	69*	39	43	26	41	37	50	25	35	N., March to May; S., October to December; W., July to Nov.; E., Nov. to Dec.

	No. of years.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms.	Months in which a certain wind prevailed.
ASIA.											
Novo Petrovsk, Caspian, . . .	(8)	52	40	60	99*	21	13	28	42	10	S.E., Oct. to Mar.: N. and N.W., July to Sept.
Tara, Tolbo'sk, ...	(10)	40	30	48	31	19	26	24	31	115*	Calms in July and August; E. January to March; N., September to November.
Agra, Central India, ...	(3)	21	22	37	19	14	22	108*	31	92	E., April to September; W., December to June.
Madras, ...	(4)	39	68	14	22	85*	76	47	14	—	S. and S.W., April to October; N. and N.E., October to February.
Colombo, Ceylon, ...	(6)	15	45	7	19	9	101*	51	10	34	W. and S.W., Apr. to Oct.; N.E., Nov. to Feb. only; S.E. in April.
Calcutta, ...	(5)	56	19	33	33	87*	36	27	21	—	N., Nov. to Jan.; S., April to Sept.
Hong Kong, China, ...	(5)	17	79	91*	62	9	33	17	18	20	E., October to March: S.E., April to September: S.W., May to August.
Nertchinsk, Siberia, ...	(10)	22	20	14	12	11	27	35	73	152*	Winds stronger, April to July; calms, Oct. to Mar.; in Dec. and Jan. 25 days.
Yakutsk, ...	(15)	67	12	20	9	33	7	28	18	171*	Calms, Nov. to Mar.; N., Nov. to Feb.
Ajan, Sea of Okhotsk, ...	(2)	26	99*	17	11	33	68	14	11	86	N.E., April to September.
Hakodadi, Japan, ...	(3)	18	1	32	75	22	26	84*	85*	22	W. and N.W., October to February; S.E., June to September, calms in March.
AFRICA.											
Funchal, Madeira, ...	(3)	42	161*	34	15	3	7	74	29	—	N.E., most May to August: N., December; W., January, February, and Sept.
Ascension Island, ...	(2)	0	2	31	167*	155*	2	1	1	6	S.E., 22 days in Oct., 9 in Dec. and Jan.
St Helena, ...	(5)	4	6	2	162*	108*	23	2	4	6	S.E., 14 days in each month.
Oran, Algeria, ...	(12)	81	79	4	15	18	55	13	99*	—	N., N.E., and N.W., April to October; S.W., October to March.
Cape Town, Cape of Good Hope,	(4)	28	0	0	23	175*	19	43	73	—	S., in January 21 days.
AUSTRALASIA.											
Fremantle, West Australia, . .	(2)	6	61	60	52	39	74*	37	35	—	N.E., May to Aug.: S.E., Mar. to May; S.W. least, and N.W. most, in July and Aug.
Melbourne, ...	(8)	59	30	48	54	64*	38	17	52	3	S., October to March; N., April to September.
Sydney, ...	(6)	14	59	45	34	49	31	72*	51	9	W., Apr. to Sept.; E., Oct. to Mar.; N.W., May to Aug.; S.E., Nov. to Mar.
Christ Church, New Zealand, .	(4)	10	94*	62	15	12	106*	17	27	22	S.W., Mar. to Sept.: N.E., Oct. to Apr.
Auckland, New Zealand, . . .	(6)	28	54	25	31	48	86*	41	48	—	S.W., least June to September.
Tahiti, Society Island, ...	(3)	21	67	87*	26	19	29	46	56	12	E., least December and January; N.E., October to March; S.E., June and July; S.W., July to September; N.W., November to May.

	No. of years.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms.	Months in which a certain wind prevailed.
NORTH AMERICA.											
Sitka, Alaska,	(8)	13	32	69	46	22	35	26	22	100*	E., October to March; W. and N.W., May to July; calms in September 12 days.
New Westminster, British Columbia,	(2)	3	24	66	49	80	30	18	6	89*	S., April to September.
San Francisco,	(3)	32	6	0	2	29	22	119*	11	143*	Calms 12 days a month; W., April to October.
Melville Island, Arctic Sea,	(1)	148*	12	24	20	24	23	35	59	22	S., May to July; N. in November 20 days.
York Factory, Hudson Bay,	(6)	62	36	36	12	60	18	21	27	94*	N., February to June; S., October to February.
Red River Settlement,	(4)	74*	11	15	13	105*	31	31	41	46	N., September to April; S., March to October.
Green Bay,	(9)	29	89*	10	12	48	125*	30	22	—	S.W., most in January; N.E., Mar. to Aug.
Fort Leavenworth, Kansas,	(10)	35	37	23	51	67	54	21	72*	6	N.W., October to March; S., May to October.
New Orleans,	(2½)	53	60*	57	56	52	22	26	28	12	N. and N.E., October to April; E., S.E., and S., April to October.
Montreal, Canada,	(4)	36	56	5	13	32	67	62	70*	24	
New York,	(4)	12	56	14	46	15	56	75	92*	—	N.W. Oct. to March. S.E. April to August.
Charleston, South Carolina,	(5)	20	97*	20	52	14	94*	14	52	2	N.W. Oct. to May, S.W. May to August. S.E. May to Sept., N E. Sept. to May.
Havana, Cuba,	(3)	37	56	132*	43	12	6	1	4	—	
Bermudas,	(3½)	36	49	32	29	42	85*	39	50	—	N. Oct. Nov. and Dec.
SOUTH AMERICA.											
British Guiana,	(6)	15	161*	69	79	23	8	1	7	—	S. July. N.E. Oct. to April.
Valparaiso,	(3)	73	29	13	15	64	52	16	26	78*	N. April to August. S. Oct. to Feb.

(1) A Trade wind.
Ascension Island.

Two Years.	*N.*	*N.E.*	*E.*	*S.E.*	*S.*	*S.W.*	*W.*	*N.W.*	*Calms.*
Jan.	0	0	2	9	17	1	0	0	2
Feb.	0	1	1	11	13	1	1	0	0
Mar.	0	0	3	11	16	0	0	1	0
April	0	0	2	10	16	0	0	0	1
May	0	0	5	15	10	0	0	0	1
June	0	0	3	15	11	0	0	0	1
July	0	0	4	17	10	0	0	0	0
Aug.	0	0	3	18	10	0	0	0	0
Sept.	0	0	3	17	10	0	0	0	0
Oct.	0	1	2	22	6	0	0	0	0
Nov.	0	0	2	12	16	0	0	0	0
Dec.	0	0	1	9	20	0	0	0	1
Year.	0	2	31	177	155	2	1	1	6

(2) A Monsoon wind.
Trincomalee, Ceylon

One Year.									
Jan.	3	24*	0	0	0	0	0	1	3
Feb.	1	19*	1	0	0	6	0	0	1
Mar.	1	15*	3	0	1	3	0	0	10
April	0	6	5	0	1	11*	1	0	3
May	0	2	8	0	1	13*	2	0	5
June	0	0	1	0	0	28*	0	0	1
July	0	1	1	0	0	27*	1	0	1
Aug.	1	1	3	0	0	24*	1	0	1
Sept.	1	0	2	2	0	27*	0	0	0
Oct.	1	5	3	1	0	13*	2	1	5
Nov.	1	9*	8	1	0	3	2	0	6
Dec.	4	22*	1	0	0	1	0	0	3
Year.	13	102	36	4	3	157	9	28	39

(3) A prevailing W.S.W. wind.
Dublin, Ireland.

Eleven Years.									
Jan.	1	1	2	3	3	9*	8*	2	2
Feb.	2	1	3	3	2	6	8	1	2
Mar.	3	2	4	2	2	6	8	2	2
April	2	3	6	2	2	6	6	3	1
May	2	2	7	3	2	7	4	3	1
June	2	2	5	2	2	6	6	4	1
July	2	1	2	2	2	7	9	4	2
Aug.	2	1	2	2	2	8	9	3	2
Sept.	1	1	3	2	3	9	7	2	2
Oct.	2	2	4	3	2	7	6	2	3
Nov.	1	1	4	3	2	7	6	2	3
Dec.	1	1	2	3	2	10	7	2	3
Year.	21	18	44	30	26	88*	84*	31	24

(4) A Polar calm.
Yakutsk, Siberia.

Fifteen Years.									
Jan.	9	1	0	0	2	0	1	1	17
Feb.	6	1	1	0	2	0	1	1	16
Mar.	5	1	1	0	3	0	2	2	17
April	6	1	1	1	3	1	3	2	12
May	5	1	3	1	3	1	4	2	11
June	3	1	4	2	3	1	3	1	12
July	3	1	3	2	5	1	3	1	12
Aug.	4	1	3	1	3	1	3	2	13
Sept.	4	1	2	1	3	1	3	2	13
Oct.	5	1	1	1	3	1	3	2	14
Nov.	8	1	1	0	1	0	1	1	17
Dec.	9	1	0	0	2	0	1	1	17
Year.	67	12	20	9	33	7	28	18	171 days.

CLIMATE—ISOTHERMAL AND RANGE LINES.

MAPS 23 and 24.

OUR earth has two great separate and distinct sources of heat. The one is internal, the central fires remaining within the now cooled outer crust of the earth, from the time when the globe was first shaped as a glowing fluid mass, and which still manifests itself, at various parts of the earth's surface, in volcanic flames, and acts in restoring slowly, by its upheaving power, the land of the globe which has been worn down by the action of the elements; the other is external—the heat radiated from the sun. To what extent the remaining internal heat of the globe still affects the temperature of its external surface is doubtful; and although the amount of heat derived by it from this source is probably very small, yet it is hardly possible to conceive that no heat escapes through the thin shell which is supposed to retain the interior mass at a temperature in which rocks, and all the most stable substances, become pliant and fluid; but this, at least, is certain, that none of the light and life-giving heat of the earth is due to this source, but is all externally received from the great centre of our system—the sun. It is this heat of the sun which causes the circulation of the waters of the ocean, which draws up the vapours from them into the atmosphere, and sets in motion the currents of air, to carry these vapours over the land, there to deposit them as rain, and fit the soil for vegetable growth and for the habitation of man; besides that, the sun gives to the world the cheerful light which is an essential to life.

The atmosphere retains little of the sun's heat in its passage, and depends chiefly for its temperature on that of the earth's surface. The air is thus dependent on the earth for its heat. But whilst the temperature of the soil is important, as regulating in great part that of the air, and the nature of vegetable productions, to man the heat or coldness of the air which he breathes, and which surrounds and affects his body, is of the greatest moment. The temperature of the air is naturally greatest above that part of the earth which remains longest vertically beneath the sun, as explained in the notes to maps 3 and 4, and least where the sun's rays approach most exactly to a horizontal direction, day and night being constant throughout the year; the greatest heat is thus experienced about the tropics, and the greatest want of heat at or near the polar circles. It is the object of the present maps to show the relative temperature of the different parts of the earth's surface atmosphere, as it most nearly affects mankind. In the course of a year, or the time of the passage of the earth round the sun, from the inclination of its axis, different parts of its surface come under the vertical influence of the sun's rays; and the angle at which these rays reach the outer parts also varies within this space of time, so causing the seasons; but the whole sum of the heat derived by each part, is found to be practically equal during each revolution round the sun, so that the average temperature of a year, at every part of the earth's surface, gives a correct means of comparison of the amount of heat received by each point, and the variation of this heat may be determined for each point by taking the difference between the greatest and least amount of heat received at any time during the year. The first of these maps, then, shows the relative *amount* of heat received from the sun, at each part of the earth in a year, the second gives the amount of the *fluctuation* of temperature at each part during this period.

Isotherms.

The Annual Isotherms are imaginary lines passing through all places, at which the average annual temperature of the atmosphere, near the surface of the earth, is exactly the same. These average temperatures are deduced by taking the mean of daily or semi-daily observations of temperature at these places for a considerable number of years; since, besides fluctuating throughout the same day and month, the mean temperature of one year may vary to a small extent from that of another, at the same place.

If our earth were a perfect sphere, entirely covered with land, without any inequalities in the smoothness, or any differences in the nature of its surface, then we might expect to find the temperature decreasing regularly poleward, and the annual isothermal lines passing round the globe in circles parallel to the lines of latitude, since there would then be no disturbing elements to raise or depress the temperature of our atmosphere in one part of these circles more than another. Then the temperature of every point might be predicated with the greatest certainty from its latitude alone, from it position relative to the source of heat, the sun, in receiving its direct or indirect rays.

Circumstances which Modify Temperature.

But the surface of our earth is by no means a uniform expanse of this kind; on the contrary, it presents the most apparently irregular confusion of land and water, of elevation and depression, which it is possible to conceive. Nearly three-quarters of its surface are covered with waters of most different depths, and the remaining fourth with land of unequal height; whilst the land presents all varieties of character, from dense forest to barren desert. All of these circumstances modify the reception of the sun's heat by the earth, and, consequently, the condition of the atmosphere over it. The sea receives the sun's heat more slowly than the land, and retains it longer; and barren land becomes more rapidly heated, and parts with its heat more speedily, than land covered with vegetation. The currents produced in the ocean by the mutual action of the sun and the rotation of the earth, are diverted by the irregular form of the intervening land, so as to carry heated waters poleward, or drive the colder waters towards the equator, far beyond their natural boundaries. We have seen also that the normal movements of the atmosphere, the trade-winds, are changed by the unequal distribution of the land; and that these land masses, now heated to excess under the vertical rays of the sun, and again overcooled by the rapid giving off of their warmth, cause periodical and variable winds, all of which affect the temperature of the air.

The temperature of the air decreases rapidly as we ascend from the surface of the earth to the higher regions of the atmosphere. This decrease may be taken at about 1° of Fahrenheit's scale for every 300 feet of elevation. Thus, it is observed, that the isotherms, on the actual uneven surface of the ground, form a series of contour lines round the elevated parts of the land, an equal rise in height having an equal decrease in temperature, so that the summits of the higher mountains, even in the tropical regions of the globe, have a constantly arctic climate, and are covered with perennial snow. But isotherms, thus drawn, would not represent the general temperature of one country in latitude, as compared with others; so that, in drawing these lines to represent the general yearly temperature of the different zones of the globe, the temperatures observed at higher stations are reduced to what they would be, if the place were at the level of the sea, by adding 1° for every 300 feet of elevation; and, consequently, in determining the yearly temperature of an elevated district from the isotherms, this correction must be deducted from the temperature shown by the lines which cross it. The lines on the Map are drawn, then, as if all the points through which they pass were at the level of the sea, at intervals of 10° of change of yearly temperature.[1]

The spaces within the lowest temperature lines, drawn on the map round the polar regions of the globe, are coloured in the darkest blue, and the areas of the tropical regions, which are included within the warmest isotherm shown, have been coloured in the strongest red; between these extremes the blue colour is continued, in lighter tints, to as far as a line of a mean temperature of the freezing point of water, 32° Fahr.; and beyond this, in the temperate regions to the tropics, the spaces between the isotherms are shown in increasing tints of red colour. Every place which lies below the same one of these lines has the same average yearly temperature. From a glance at these lines then, it is evident, that in the Northern Hemisphere especially, the irregular distribution of land and water destroys their arrangement according to latitude, and that any one of the parallels of latitude, which, from their equal distance from the direct vertical action of the sun, might naturally be expected to receive

Abnormal arrangement of the isotherms in the Northern Hemisphere.

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[1] The lines here represented are those of Dové, recently revised, cially in the tropics, by Buchan.

an equal amount of heat, passes through a great variety of yearly temperatures in its course round the globe. Thus, following the parallel of London, which starts from that place with a yearly temperature of 50°, we find the temperature falling gradually as we pass towards the continent eastward, to 40° in Eastern Russia, to 32°, or a mean temperature of the freezing point, in Central Asia, and to below 30° in Eastern Siberia; the temperature rises gradually to a mean of 40° as we enter the Pacific, and to 50° again, on approaching the west coast of North America, sinking, as we advance through the continent, to 40° in British America, and to 30° on the eastern side, then rising slowly to 40° in the centre of the North Atlantic, and again to 50° in the British Isles.

This line exemplifies the distribution of the annual temperature of the greater part of the Northern Hemisphere, especially of that part which lies above the 40th parallel of latitude: and it brings out these main facts, that the land is, on an average of the year, colder than the sea, and that the central and eastern parts of the two continents of Europe and Asia, and North America, along with the sea next to the eastern coasts, are colder than the western side, with its sea.

The isotherms form a series of rude ellipses in this portion of the Northern Hemisphere, whose major axes are in a line, joining the eastern coasts of the continents and the minor, in a line connecting the western coasts.

The explanation of the generally greater warmth of the sea than the land lies in this, that the sun's rays penetrate to a considerable depth into the sea, and only heat the surface of the earth; then though the sea requires a longer time to attain the same temperature as the land under the influence of an equal heat, yet, the warmth once received, is, as it were, stored up in its depths to rise when the surface is cooled; but the land having no such reserve of warmth, parting with its surface heat in winter, becomes then very much colder than the sea.

The higher temperature of the western sides of the two continents of the Northern Hemisphere, and of the seas next to them, is accounted for by the prevailing westerly winds, the anti-trades, which (Map 22) blowing directly on the western coasts of Europe and North America, above the parallel of 40° N., almost constantly throughout the year, in a return current of air from the warmest regions of the globe, carry this warmer atmosphere to these coasts, and so raise their temperature far above that which is due to them by their latitude. The annual temperature of the British Isles is thus raised as much as 11° above[1] the normal temperature of their position on the globe; and the west coasts of North America, in the same latitude, are benefited to the amount of 7°, a less increase of temperature, since the winds which cause the warmth travel over a much longer distance of sea in the Pacific than do those of the Atlantic. Again, two areas in the eastern parts of these continents, one in Eastern Siberia, the other in British America, north of Hudson Bay, near the Arctic Circle, are called the poles of cold. Both are 11° below their normal temperature, each being the centre of an outflow of air to all sides in winter, under a high barometric pressure, and consequently receiving an inflow of colder air from above, their winter temperatures are reduced to the lowest experienced on the globe.

Coldest Areas.

Below the fortieth parallel of latitude, in the northern hemisphere, the isothermal lines retain the form of those to the north of them, carried northwards by the influence of the sea, and southwards by the land, though in a far less degree, till we arrive near the warmest areas shown on the Map, inclosed by the isotherm of 80° of mean temperature.

This warmest isotherm surrounds two tropical areas, shown on the Map by the darkest red colour. One extends from Africa far into the Pacific; the other surrounds the equatorial part of the South American continent. The greatest heat thus appears to concentrate over the land surface within the tropics, and in those seas which are enclosed by land; for where the oceans have a free space to disperse their heated surface waters over the colder parts of the ocean by means of currents, as in the Atlantic and Pacific, there the annual temperature is less; but it is probable, from the long continuance of the vertical sun over the outer part of the tropics, that the heat on the outskirts of this region is greater than that within or more directly on the equator. The North Indian Ocean has no outlet for its overheated waters on the north, so that the highest surface temperatures of the sea are recorded in this part of the ocean; and the East Indies, and the many island groups of the Eastern Pacific seem to act together as a continent in retaining the heat.

The region of the globe which becomes hottest is that which extends from Eastern Africa across the Red Sea, Arabia, and the Persian Gulf, into Southern Persia, on the edge of the northern tropic. This area has a mean tem-

Hottest Region.

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[1] Dove's Lines of Isabnormal Mean Annual Temperature.

perature of 95° in July, and is, on an average of the year, four and a-half degrees above the normal temperature due to it in latitude.

Southern Hemisphere.

In the Southern Hemisphere, less disturbed by great land surfaces, the isotherms follow more nearly the course of the parallels of latitude; but here conditions the reverse of those of the Northern Hemisphere are observed, and the western sides of the continents are the colder. This is especially noticeable in South America, where, on the west coast, the trade-wind brings a cooler atmosphere from the southern regions, and a cold antarctic current prevails along the coast, reducing the temperature; whilst, on the eastern side, the partial returning of the Atlantic south-east trade-wind from the tropical regions, conveys warmer air to the eastern coasts.

South Africa is likewise warmed on the eastern side by the heated air and water from the North Indian Ocean, and its western side has the beginning of the cooler trade-wind, and a cold current from the antarctic regions.

MAP 24.

These lines, of equal mean annual temperature, noticed above, are sometimes termed 'climate lines;' and one is very apt to imagine that every place which lies under the same isotherm has the same climate. This, however, is by no means the case; first, because there are many circumstances which go to form a climate besides temperature, though that perhaps is the chief; and, second, because the same mean annual temperature may be formed between very different extremes of heat and cold in winter and summer; and even if these winter and summer extremes, and the average temperatures, were the same at two separate places,—a very rare coincidence, as shall presently be shown,—it would most probably be found that their *daily* extremes of temperature were very different; so that it remains very doubtful whether there are on the land of the globe any two places with exactly the same climate. This range of temperature, then, becomes quite as important in determining a climate as the knowledge of its mean temperature.

This subject has been divided by meteorologists into the two main heads of *diurnal* and *annual* range; the former being measured by the variation of temperature between the warmest and coldest hours of the day; the latter by the difference of temperature between the warmest and coldest months of the year. These branches of the subject are equally important, for it is perhaps as necessary to know the rapid change which the temperature of a place may undergo in the course of a day and night, as the more gradual change which occurs in the course of the year; but for a study of *diurnal* range we should require a series of observations for every hour of the day and night from all parts of the earth, and the points at which laborious observations have been made are as yet very few; the returns of daily and monthly temperatures, however, now obtainable from all countries, are sufficient for a tolerably complete study of the simpler head of *annual range*. It is believed that the subject of annual range has never before been systematically worked out for any large portion of the earth's surface, though its general conditions may have been recognised from the comparison of a few isolated points.

In preparing the maps of annual range for the Atlas, it was first assumed that the months of January and July are respectively the coldest and warmest months of the northern, and the warmest and coldest months of the southern hemisphere. This proves to be the case, with few exceptions, in all parts of the earth, excepting those near the equator, which have two maxima and minima; but the annual range of temperature in these regions is so very small, that the difference between the temperature of January and July may be taken as the measure for every part of the earth where range is considerable. January and July temperatures were then collected from all available sources, and, their differences being taken, the annual range of twelve hundred places, in all countries, was obtained. These figures were then set down on the maps on the position of the places of observation, and lines were drawn through those places which have an equal range at intervals of 20° of increase, thus presenting the subject in a graphic form. The parts of the earth's surface which have a *less* annual range of temperature than 40° have been tinted in red, the strength of the colour increasing as the range diminishes; and those regions which have a *greater* range than 40°, in blue, the strength of the colour increasing with the range.

Line of no Range. At the point where January and July, the coldest and warmest months of the northern hemisphere turn to January the warmest, and July the coldest months of the southern hemisphere, we find a line passing round the globe on which there is no difference between the temperature of these two months. It is observed that the course of this zero line is very far from coincident with the mathematical equator of the globe, and that the parts of it which pass through the land masses are in the northern hemisphere, in Africa, India, and South America; whilst those which pass through the Atlantic and Pacific Oceans, are carried far into the southern hemisphere. The lines of 20° and 40° of range show a marked parallelism with respect to each other in the northern hemisphere, being carried far to the north in the Atlantic and Pacific Oceans, and to the south, in their passage through the continents, entering their *west* coasts in high latitudes, and leaving their eastern shores in much *lower* latitudes.[1]

Line of 20° Range. The line of 20° range in the northern hemisphere is one of the most interesting of all, since it shows, in the most marked manner, the difference of range between the west and east coasts of the continents. It passes through North Africa and Southern Asia, carried to the north at the Red Sea, and Persian Gulf, leaves the east coast of Asia at Macao, near Hong Kong, in 15° N. latitude, runs well into the Pacific, keeping away from the Asiatic coast, and reaches the American west coast in latitude 55° N., or 40° further to the N. than where it left the Asiatic coast, then it turns south to Mexico, across the north of the Gulf of Mexico to Florida, leaves the east coast between latitude 25° and 30° N., then into the Atlantic to the Bermudas, after which, bending due north-east, it reaches as far as Iceland, and perhaps Spitzbergen, before turning south to the Norway coast, again showing, as in the Pacific, a difference of 40° in latitude between the same range on an east and west coast. From the coast of Norway, at Stavanger, this line of 20° range dips down into the North Sea, then rises northwards along the coast of Scotland to Braemar in Aberdeenshire, bends thence to the west and south-west to between Glasgow and Greenock, then down the west coast of England by Liverpool and Chester, and Pembroke in South Wales, to Devonport on the coast of Cornwall, then along the south coast to the Isle of Wight and the Channel Islands, thus enclosing the main part of Great Britain with a greater range than Ireland, though the central and eastern parts of that island have a range of little less than 20°. The difference of range between the south-east coast of England and the west coast of Ireland is nearly 10°.

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[1] For a more particular description of the range lines, see the Author's paper in the Proceedings of the Royal Society of Edinburgh, vol. vi. It is to be regretted that the small scale of the map prevents the insertion of the range lines for every 10° to correspond with the isothermal map, the crowding of the lines, in some parts, having been found to be too great for clearness.

The line of 20° range then passes along the west coast of France and Spain, bending completely round the south-west and south coasts of the peninsula, through Lisbon, Cadiz, and Gibraltar into the Mediterranean, where it seems to form a great loop, extending to the east nearly as far as Alexandria (21° range), touching in its return at Tunis, Algiers, and Oran, in North Africa, and keeping along this coast as far as the Atlantic shores of Marocco, where it turns into the interior of Africa.

Line of 40° Range.

At 40° of range the lines begin to keep to the land masses—no part of the *open* ocean, in any part of the globe having a range of more than 40°. In North Africa we find a large area of the Sahara with this range, where the north part of the line 40° reaches to within a hundred miles of the Mediterranean in Algeria, and extends probably south to the 20th parallel of N. latitude. Taking up the line in Asia, we find it passing completely round the interior of Asia Minor, at no great distance from its coasts, then through Damascus into Arabia, round the head of the Persian Gulf, and through the Punjab, south of Peshawar, to the table-land of Tibet and the coast of China, near Shanghae; thence it turns north-east through the Yellow Sea to Hakodadi, in the north island of Japan, along the line of islands to the east coast of Kamtchatka, near Petropaulovsk, across the Behring Sea to the peninsula of Aliaska; thence down the west coast of America, close to the lines of less range, to the 35th parallel of N. latitude, where it turns east across the continent to the west coast at Chesapeake Bay; thence it skirts the coasts of Nova Scotia, touches on Newfoundland at St John's, and, taking a northern direction, reaches the Greenland coast near Disco Island. Carried south by the influence of Greenland, it leaves the east coast, perhaps in the latitude of Iceland, and stretches thence probably beyond the North Pole, returning to the islands of Novaia Zemlia, where observation at two points gives a range of only 39°. From this the line of 40° range keeps near the north coast of Russia, and passes down through the centre of the Scandinavian peninsula, by Christiana and Gottenburg to Stockholm, is carried northwards into the Gulf of Bothnia, then half way into the Gulf of Finland to Helsingfors, along the coasts of the Baltic provinces, and southwards through central Europe to Vienna. As we found the chain of the Pyrenees breaking the line of 30° range, so here we observe that the mass of the Alps isolates the part of this line of 40° which marks out the plain of Northern Italy. Another separate area, of above 40° range, is observed in the valley of the Ebro, in North-East Spain, and the heights of the Carpathians and Transylvanian Alps form a third exceptional portion, since, though within the main line of 40° they have a slightly less range. From Vienna the main line of 40° passes round the Hungarian plain, through Turkey, to the north of the Balkan range, across the Black Sea south of the Crimea, into Trans-Caucasia, nearly as far as Tiflis, and thence bends back again round the coasts of Asia Minor.

Line of 60° Range.

The line of 60° range, and those above it, are confined to the Asiatic and American continents, and may be called land lines. Taking up the line of 60° of range in the north of European Russia, we observe it making a bend to the north-west round the town of Krasnoiarsk (which has a range of 65°) back again eastward to the Ural Mountains beyond Ufa, then forming a second western projection to as far as Kharkov, on the north of the Sea of Azov, passing back round the east side of the Caspian Sea, and sending out a narrow tongue-like extension through Northern Persia and the town of Urumiah towards Asia Minor, then returning eastwards through Central Asia to the south of the town of Ili in Eastern Turkistan (62° range), through China, with a probable bend to the southward, rising again to near Pekin and Tientsin, through Manchuria, near its coasts, to Port Ayan (60°), on the Sea of Okhotsk; thence this line seems to pass round the north-eastern projection of Asia, and to turn westward through the Arctic Ocean, but not far from the land, to the north of the Ural chain, where it enters Russia.

In America, taking up the line of 60° range at Port-Clarence on the coast of Behring Strait, we find it passing down into the interior to the east of British Columbia as far as Oregon, then following the same curves as the line of 50° range through the centre of the continent, to the north of the lakes, and bending round with the coast in Eastern Canada and Labrador, northwards through Melville peninsula and Baffin Bay to Greenland in latitude 75° N. After passing through Greenland, it most probably bends backwards along its northcoasts and those of the islands of the arctic archipelago, to where we find proofs of its existence in the westmost of these islands, thence to the north coast of America, along which it runs south from Point Barrow to Behring Strait.

A third area, which we find surrounded by a line of 60° range, is that in the north-east of Norway, in Lapland, and in the Kola peninsula. This line reaches as far south as Umea on the east coast of the Gulf of Bothnia, and passes just to the west of Tornea, at the head of the gulf; thence across to the White Sea, and embracing the Kola peninsula and the coast to westward of the Waranger Fiord, to where it enters Norway.

Line of 80° Range.

From Tara, in the government of Tobolsk, in Siberia, the Asiatic line of 80° range passes eastward to the north of Lake Baikal, and then south between that lake and the town of Chita, which has a range 85°, probably far into the desert of Mongolia, then north-eastwardly parallel with the lines of 70° and 60° range, but further inland to the north of Nijnie Kolymsk (85° range), and along the north coast westwardly to beyond the mouth of the Lena, where it probably re-enters the continent, and passes south-west through the government of Tobolsk to Tara. The observing stations on the chain of lakes in America which stretch north-west from Lake Winnipeg, have all a less range than 80° till we arrive at the most northerly, the Great Slave Lake, whose north coast at Fort Confidence has this range; but two belts of country, one on each side of this lake region, appear to have a range of upwards of 80°. These two belts unite at the north of the Great Slave Lake, and stretch out thence westwards into Alaska territory, and eastward as far as Victoria Land and Boothia. A solitary observation of 93° of range, on the Yukon River in the centre of Alaska territory, might justify the enclosing of a small area in that region as having a range of above 90°, and this is certainly the part of the American continent which has the greatest range.

In Asia, the area which has a greater range than 90°, probably extends in Siberia from the Yenisei River on the west to the Stanovoi range of mountains in the east, and from near the north coast (where at Ust Yansk we find a range of 92°) to the Yablonoi range in the south. The town of Chita, to the south of these mountains, has a range of 85°. A smaller area in the interior of this one must be surrounded by a line of 100° of range.

Greatest Range of Temperature.

Near the centre of this terrible region is Yakutsk, the point of the earth's surface which has the greatest range of temperature, whose climate undergoes a change, between the months of January and July, of the fearful amount of 106° Fahr.

Southern Hemisphere.

In the Southern Hemisphere the line of 20° range is divided into three parts. The coasts of South Africa have nowhere an observed range of more than 16°; but in the interior, an area showing slightly more than 20° of range, extends from near the coasts of Cape Colony inland, to perhaps 10° or 15° S. latitude. Within Australia a line of 20° range passes from near Perth, in Western Australia, along the south coast, then close to the east coast (Brisbane and Newcastle showing 20° and 19° of range), and across the continent again westwardly, near the parallel of 20° S. latitude. The third line of 20° range enters the west coast of South America in about latitude 40° S., passes north near the coast to 25° S. latitude, turns inland round the northern boundaries of the Argentine Confederation and Paraguay, and then curves round south and south-west to Monte Video on the east coast; thence it runs due south, round the Falkland Islands, which have a range of 16° to 18°, crosses the ocean towards the Cape of Good Hope, and east to New Zealand, passing through the south-eastern parts of both its islands, and from that over the Pacific to South America.

The central and eastern parts of Patagonia have the highest range in the Southern Hemisphere, and this does not exceed 40°—observations at Mendoza, in the north, giving only 38° of range.

Contrast of Range in Northern and Southern Hemispheres.

A most striking contrast, due to the unequal distribution in amount of the land and water, is presented by a comparison of the range in the Southern Hemisphere with that of the Northern. The highest observed range in the Southern Hemisphere is that of a small area of Patagonia, which is surrounded on the map by a line of 40° of range. This area does not cover a *hundredth* part of the surface of this hemisphere, whilst perhaps a *third* part of the Northern Hemisphere has a range of above 40°, rising in one part to above 100°.

Variation of Range on the Annual Isotherms.

With a view to showing the variation of range in those parts of the earth which have the same mean annual temperature, six of the annual isotherms have been opened out, as it were, on each side of the meridian of Greenwich, and the amount of range for each point of these lines has been projected vertically above it, giving remarkable curves, of which the one shown beneath the chart of the annual isotherms is a sample.

On the isotherm of 10° in the Northern Hemisphere, it has been found that the range may vary from 30° in the Arctic Ocean to above 100° in Eastern Siberia, near Yakutsk. The mean range on this isotherm is 65°.

The isotherm of 20° has also a mean range of 65°, but may have as little as 25° in the Arctic Ocean, and as much as 100° in Asia.

On the isotherm of 30°, or nearly a mean annual temperature of the freezing point, the range may vary from below 20° between Greenland and Norway, to above 90° in Eastern Asia, the mean range on this line being 60°.

The isotherm of 40° shows a variation of range of from less than 20° in the Atlantic Ocean south of Iceland and in the North Pacific, to above 80° in Mongolia; whilst the mean range is 47°.

The line of 50° of mean annual temperature has a mean range of 41°; but this varies between 20° in the west of Ireland, to above 80° in Asia.

On the isotherm of 60° we find a mean range of 40°, but only 10° in the Pacific, and above 70° in Central Asia.

From these curves, then, it is evident that hardly any two regions having an equal mean temperature, even though of small extent, and at a very short distance from one another, have an equal amount of range, and that the places on the earth's surface in which these two conditions of equal mean annual temperature and equal annual range are the same, are very few and far between.

Variation of Range in Latitude.

Again, to show the variations of range in the same latitude, some of the parallels of the Northern Hemisphere have been taken as basis lines, as the isotherms were in the former instance, on both sides of the first meridian, and the range on each point has been projected up from these as before, giving curves analogous to that shown below the Southern Hemisphere of the accompanying range chart.

One of the peculiarities shown by the curves thus produced, is that of the smallness of the range on seas and lakes, and the great amount on the land surface of the globe, as also the very immediate increase of range from some coasts towards the interior of the land. But by far the most interesting and curious feature presented by this diagram, or indeed by the whole subject, is that of the difference in the amount of range on the opposite coasts of continents and seas.

Contrast of Range on East and West Coasts.

In the temperate regions, and even to some distance beyond these into the torrid zone and the arctic regions, *the range on coasts facing west is invariably less than that of coasts facing east, in the same latitude*, and this holds good not only in the case of great seas and land masses, but also on the shores of inland seas and lakes.

The comparison of the range at a few places in the same latitudes, but on the opposite coasts of the continents, given in the following tables, may serve to show the great amount of this difference.

In North America—

Latitude N.	*West Coast.*	*Range*	*East Coast.*	*Range.*	*Difference of Range*
57°	Sitka, . . .	23°	Port Nelson, Hudson Bay,	65°	42°
			Nain, Labrador,	52°	29°
43°	Port Orford, . .	11°	Boston, . . .	44°	33°
37° 30′	San Francisco, .	8°	Richmond, Virginia, .	40°	32°
32° 30′	San Diego, California, . .	21°	Charleston, S. Carolina, .	31°	10°
			Mean Difference, ...		29°

The mean difference of these temperate coasts of North America, as determined by the crossings of the range lines on every fifth parallel of latitude, is 25°.

In Europe and Asia—

Latitude N.	*West Coast.*	*Range.*	*East Coast.*	*Range.*	*Difference of Range.*
60°	Bergen, Norway,	25°	Okhotsk, . . .	66°	41°
57°	Riga, Russia, . .	41°	Port Ayan, Sea of Okhotsk,	60°	19°
	Mandal, Norway,	28°			32°
51°	Ostend, France, .	26°	Mariinsk (Amur),	55°	29°
40°	Lisbon, ...	15°	Pekin, ...	56°	41°
31°	Jerusalem, . . .	28°	Shanghae, . .	43°	15°
22°	Djedda, Arabia,	8°	Canton, . . .	35°	27°
			Mean Difference, ...		29°

The difference of range on these coasts, determined as before from the range lines, is again 25°, the same amount as formerly obtained for North America, thus establishing a close agreement in the relations of the coasts of these two continents.

The mean difference between the east and west coasts of that portion of North Africa which falls in the temperate regions is 10°, the Red Sea coast having that amount of range more than the Atlantic coast.

Valparaiso in South America, in latitude 33° S. on the west coast has a range of only 9°, and in latitude 35° S. on the east coast we have Monte Video and Buenos Ayres, with ranges of 21° and 25°, thus showing a difference between the coasts at this point of 14°. The range lines give a mean difference of 12°.

Observations on the west coast of South Africa, in the temperate region, are entirely wanting; but since the line of no January and July range falls 10° of latitude farther to the south in the Atlantic on the west, than it does on the east coast, where it just reaches the equator, it may perhaps be assumed that the west coast of South Africa has also a less range than the east, probably amounting to 5°.

In the temperate regions of South Australia the range lines give a mean difference between the coasts of 10°, the range on the *east* coast again predominating to this amount.

Taking a mean of all these differences, we find that, *in the temperate regions of the globe, the west coasts of the continents have* 15° *less range than the east coasts*, and it has been seen that this difference may rise to above 40° in the same latitude.

An examination of the ranges on the coasts of inland seas, and even lakes, leads to the same general conclusion.

In the *Mediterranean* the following places—Alicante (30°), Valencia (40°), Barcelona (30°), Perpignan (36°), Montpellier (36°), Catania (39°), and Athens (38°), on *east* facing coasts, give a mean range of 36°; whilst Oran (21°), Algiers (21°), Palermo (25°), Naples (29°), Rome (30°), Corfu (28°), and Beyrout (28°), give a mean of 26° for the *west* facing coasts, or a difference of 10° between the two.

The mean of Odessa (47°) and Constantinople (33°) gives 40° of range for the *east* facing coast of the *Black Sea;* and Trebizond (29°) and Redut Kale in Caucasia (31°) give 30° as the range of the *west* facing coast; again showing a difference of 10° less on the latter coast. On the *east* facing coast of the *Caspian Sea*, taking the observations at Astrakhan and Lenkoran (58° and 42°), we have a mean of 50°, whilst Novo Petrovsk, the only observing station on the *west* facing coast, has 47° of range; Fort William (58°) and Bay City (55°) give 56° as the mean range of the *east* facing coast of *Lake Superior;* and Michipicoten, in the centre of its *west* facing coast, has only 46° of range again showing a difference of 10°.

The causes of this uniform predominance of range on east coasts over west, might form an interesting subject for investigation. On no two continental coasts do we find exactly the same prevailing conditions of winds and currents, much less of elevation and form, so that the explanation of this phenomenon must rather be looked for in a special combination of these influences for each individual coast, than in any one cause acting over the whole earth's surface.

Variations of Temperatures forming the Range Lines.

The lines of equal range are formed between varying January and July temperatures in different parts of the globe. To show the manner in which these lines of equal range move up and down the thermometer scale in their passage round the earth, a few of the range lines in the northern hemisphere have been opened out, as the isotherms were before, and the January and July temperatures of each part of these has been projected vertically on the thermometer scale. The curved lines thus obtained, and of which a specimen is given under the northern hemisphere of the range map, show the fluctuations of the temperatures forming the range lines of these amounts; the upper line shows the *July*, and the under line parallel to it the *January* temperatures, according to the scale given at the side of the lines. These curves are just the converse of those which indicate the variation of range on the same isotherm.

From this we observe that the line of 60° range lies between the temperatures of 30° Fahr. in January, and 90° Fahr. in July at its *maximum*, in Persia, and between—20° Fahr. and + 40° Fahr. in Baffin Bay at its *minimum*.

The line of 50° of range, again, has its maximum in Central Asia between 40° Fahr. in January, and 90° Fahr. in July, and its minimum in the Arctic Sea between—15° Fahr. in January, and + 35° Fahr. in July.

Forty degrees of range stands *highest* on the temperature scale in Arabia and Persia between 95° Fahr. in July, and 55° Fahr. in January; and is at its *lowest* point between—5° Fahr. and + 35° Fahr. in the Arctic Sea.

The line of 30° of range has its maximum in Central Africa between 95° Fahr. and 65° Fahr. in July and January, and its minimum between + 5° and 35° in the North Atlantic.

Lastly, the line of 20° of range is at its highest temperature in Central Africa between 95° Fahr. and 75° Fahr. in July and January, and at its lowest in North Norway between 47° and 27° Fahr. The next lowest temperatures on the line of 20° fall in the British Isles, between 38° in January and 58° in July at Braemar in North Scotland, and 42° in January and 62° in July at Ventnor in South England.

Places which have the same Climate in Temperature.

The points on these range lines which pass through the same isotherms, or whose January and July temperatures are respectively at the same heights on the scale, have, so far as regards temperature, exactly the same yearly climate. Thus, on the line of 60° of range we may compare Minnesota in the United States of N. America with South Russia; on the line of 50° range, the Great Salt Lake region in America, with the Caucasus in Europe; and the east coast of China in Asia, or the American Lake district with that of North Russia. Again, on the line of 40° range, Newfoundland has exactly the same climate as the Baltic provinces of Russia, and the coasts of Kamtchatka may be compared with those of North Norway, or *Hakodadi* in Japan, with *Vienna* in Austria.

On the 30° range line we find the north coasts of British Columbia comparable with those of North Norway, *Paris* with *Fort Vancouver* in Oregon, and the south of Spain with the north of Mexico; and lastly, on the 20° range line, Macao Island near Hong Kong, in China with the same climate as Florida, in America.

Diminution of Range for elevation.

A point worthy of notice, but for the establishment of which few data are as yet to be had, is that of the apparent diminution of range on elevated parts of mountains or mountain chains. The best authenticated example of this is presented by the Alps of Switzerland. Observations for ten and twenty years at the St Gothard and St Bernhard hospices, at elevations of above 6000 feet give a range of only 27° for each, whilst the plain of Italy to the south has a range of upwards of 40°. This diminution for elevation is also observed in stations in the Pyrenees, the Transylvanian Alps, and the Himalayas.

Uses of the Range Map.

By the aid of these maps of annual range we can at once predicate of any point of the earth's surface whether it has a uniform and even climate, or an extreme one, or what precise place it holds between these limits. These maps may thus be of considerable utility in themselves, but it is when taken as companions to the annual isothermal charts, that they have their highest value. From the *isothermal map* we may find that any required place has a certain mean yearly temperature; but there is no means of ascertaining from it how far the temperatures of its coldest month may descend, or how high its warmest month may ascend the thermometer scale. Again, from the *range map* taken by itself, we can only tell that the climate of the place in question is limited to a certain number of degrees, without being able to say what position these degrees occupy in respect to heat and cold. But let the maps be used in company, and then all that is required may be obtained. First, from the one chart find the mean annual temperature of the place, and from the other its annual range; then, *since the mean annual temperature of places in the temperate and arctic regions of the globe corresponds very closely with the midway point between their January and July temperatures*—If the one-half of the amount of the range be added to, and the other half be taken from, the mean annual temperature on the thermometer scale, we have at once the temperatures of the warmest and coldest months, and the yearly temperature of the place, a knowledge sufficient for almost every purpose. This is best illustrated by an example. If from the isothermal map the mean annual temperature of Paris be taken, we find it 52°, and from the other map its annual range is 30°; then the mean annual temperature *plus* the half of this range gives

$$\left.\begin{array}{l}52^\circ + 15^\circ = 67^\circ \text{ the July temperature, and}\\ 52^\circ - 15^\circ = 37^\circ \text{ the January temperature}\end{array}\right\}\text{ of Paris.}$$

The chart of annual range is thus a useful companion to the isothermal chart, and used together, these form a very complete guide to the temperature of the globe.[1]

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[1] The Author has much pleasure in returning his best thanks to Mr Buchan, Secretary of the Scottish Meteorological Society, for much assistance in the preparation of the materials for the maps, and for placing at his disposal a large private and unpublished collection of temperatures in all parts of the globe.

EARTHQUAKES AND VOLCANOES

MAPS 25 and 26.

Thickness of the Earth's Crust.

EARTHQUAKES and volcanoes are different manifestations of the same force under different conditions, and this force is one caused primarily by subterranean heat. It is supposed that the earth still retains a large proportion of the heat which it had acquired at the period of its first formation. This would seem to be borne out by the results of observations made in deep mines and artesian wells, chiefly in different parts of Europe, where the temperature has been found to increase with the depth, in amounts varying from 1 degree in 37, to 1 degree in 208 feet. From these observations it is evident that, if this increase of temperature were uniform, a point would soon be reached at which the heat would be so great as to melt all known substances; and various authorities have accordingly estimated this limit to the solid part of the earth's crust to be between 22 and 65 English miles. The exceedingly small proportion which a shell of either of these depths bears to the whole mass of the earth, is shown in the diagram at the foot of Map 25, where these thicknesses have been drawn to scale. More recently, the late Professor Hopkins has attempted to determine the least thickness of the solid crust by a solution of the problem of the precessional motion of the pole of the earth, caused by the attraction of the sun and moon on the protuberant parts at the equator; for, if these parts were solid to a great depth, the motion thus produced would differ considerably from that which would exist, if they were perfectly fluid; and the comfortable conclusion arrived at is, that the minimum thickness of the earth's crust cannot be less than one-fourth or one-fifth of the earth's radius, or from 800 to 1000 miles. It seems most probable that there is no definite limit to the thickness of the crust of the earth, and that the distance between the surface and the molten matter beneath may vary in different parts of the globe, being perhaps closer to the surface in the regions of volcanic upheaval, and further from it under the areas of supposed subsidence. It has been suggested, that the crust of the earth has a cavernous structure, throughout which more fluid and more solidified parts may be distributed unequally to a great depth.

Causes of Earthquakes.

If a great central molten mass, on which the crust of the earth seems to float, be admitted, it is generally supposed that the explosion of immense volumes of elastic gases or steam, generated by the influence of this vast source of heat, would be sufficient to produce earthquakes. A theory of their cause, advanced by the late Professor Rogers of Boston, is that of an actual pulsation of the subterranean fluid propagated in the form of waves from enormous ruptures caused by the tension of elastic matter, and floating forward with it the rocky crust of the earth, since all upraised or depressed tracts of the earth's surface present the form of one or many solidified waves. Again, an attempt has been made to show a connection between the occurrence of earthquakes and ocean tides, or the position of the moon and sun in respect to the earth, a terrestrial as well as an oceanic tide being supposed, one in which the solid mass of the earth's crust, and the liquid or semi-liquid nucleus beneath is supposed to be an ellipsoid, with a major axis perpetually following the motions of the moon and sun; any interruption of this movement causing an earthquake, or an eruption from the nearest volcanoes.

The conclusion arrived at by the brothers Mallet is, that 'it is much more probable that all volcanic phenomena are due to conversions of electrical, or magnetic, or thermic, forces, into heat, than to a universal ocean of incandescent and molten lava beneath our feet, with a thin crust of solid matter covering it, the present or historical existence of which is not only *not* proven, but for which no argument of weighty probability has been advanced.'

Scrope, in the general conclusion to his work,[1] maintains that 'There is reason to believe that the originating cause of the changes in the crust of the earth, is the unequal transmission through it of heat from beneath upwards, owing to the variations in the covering surfaces from the deposition of marine and other aqueous sediments at the bottom or on the shores of the ocean, and the abrasion of the land; heat being thus driven to accumulate partially, increasing in some parts, diminishing in others, according to the varying weight and conducting powers of the overlying masses. When the temperature is increasing, and the subterranean matter consequently swelling, the area above suffers elevation with all its accompanying phenomena: where it is decreasing, the overlying subaqueous or subaërial areas undergo depression, from the shrinking of the matter below.'

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[1] 'Volcanoes, the Character of their Phenomena, their Share in the Structure and Composition of the Surface of the Globe, and their relation to its internal forces. 1862.'

Distribution of Earthquakes.

The map showing the *geographical distribution of earthquakes has been prepared from that which accompanies the* discussion of the British Association Catalogue of Earthquakes, by Messrs Mallet.[1] This wonderful catalogue is a record of the earthquakes, commencing at B.C. 1606, and extending to A.D. 1850; and perhaps represents the greatest amount of research which will ever be devoted to this subject. The only differences between the map given here and that accompanying the catalogue is, that in this the two centres, or what may perhaps be called the *poles* of greatest volcanic disturbance (the areas round the Caribbean Sea in the west, and of the Sunda and Philippine Islands in the east), have been brought into the centre of their respective hemispheres, and this map being on a much smaller scale, a number of the graduated tints represented in the other, have necessarily been omitted. The map represents the whole catalogue in a graphic form, subject to certain rules as to the limits assigned to the various earthquakes. The whole earth's surface known to be subject to earthquakes will be found tinted more or less intensely. The more deeply tinted surfaces mark the places where either the number or the intensity, or both, of successive earthquakes are the greatest, and the shading is due to superposition of tints only. Hence it follows that the tinting upon the map does truly represent over our earth the known seismic regions in form and extent, and the relative intensities of action therein, and is a first approximation to the true representation of the distribution of earthquake forces over the surface of our world.

The surface of our globe consists of a number of saucer-like depressions, when large having also convex central areas, all having plan outlines approximating to irregular ovals, and bounded by mountain chains, or mere rounded flat-topped ridges or elevations of the solid sphere, greater or less. The normal type of distribution of earthquakes is that of bands of variable breadth, which generally follow the lines of elevation dividing the great oceanic and terrestrial basins, and the surfaces of minimum or no disturbance are the central areas of these basins. The greatest saucer-like concavities either form or subdivide the beds of the ocean, but other such shallow basins can be traced upon the existing land, and embrace seas or parts of seas, or great lakes or river courses within them, but still enclosed by girdling chains of mountains, or the precipitous flanks of table-lands. It is along these girdling ridges, whether mountain chains, or mere continuous elevations which divide these basins beneath the ocean, that all the volcanoes known to exist upon the earth's surface are found scattered in an unequal manner.

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[1] Earthquake Catalogue of the British Association, with discussion by R. and J. Mallet. 1852–1858.

Volcanoes.

The neighbourhood of water seems to be indispensable to the existence of a volcano, so that all active volcanoes are found close to the sea, or to some large body of water, the greatest volcanic belt of the globe being that which surrounds the coasts of the Pacific Ocean. The normal shape of a volcanic mountain is that of a cone, with a circular depression in the summit known as the *crater*, through the bottom of which a narrow vent communicates with the subterranean fires. The *crater* is of variable size and depth, and may sometimes measure several miles in circumference. Most of the active volcanic mountains have many minor cones on their slopes or near their base, produced by lateral eruptions.

The number of volcanic vents over the globe has been estimated at above 400 (Humboldt gives a list of 407); but if to this number be added those probably existing in the unexplored parts of the earth, and below the seas, this number must be greatly increased. The number of volcanoes presently active, in greater or less degree, and emitting lava, flames, sulphurous smoke or mud, is perhaps not over 200; or 90 in Asia in the volcanic region between Kamtchatka and the antarctic regions; the same number in America in the region between the Aleutian Islands and Cape Horn, embracing the Western Atlantic and Eastern Pacific; and perhaps 20 in Europe and the Eastern Atlantic.

Representative Volcanoes.

The Mountains of Aconcagua, 23,301 feet, and Cotopaxi, 18,875 feet, may be taken as the representatives of the South American volcanic region. Cotopaxi is an active volcano, with a remarkably regular cone. The snow line reaches down 4400 feet from its summit, and the flames of its eruption have been observed to rise at least to this height above the crater. The volcano of Agua is perhaps the highest active volcano of Central America. It derives its name either from its having at one time erupted water, or from the heat of the volcanic matter having melted the snow on its summit. Mouna Loa, the highest active volcano of the Sandwich Islands, is 13,760 feet in height. A tremendous eruption of this mountain took place in 1843, and since then it has been frequently in action. On its slope, at an elevation of 3873 feet, there is one of the most remarkable craters in the world. It is an immense gulf, in the form of a crescent, about two miles in length, and nearly a mile in width, and is apparently 800 feet deep. The bottom is covered with lava, and parts of it are one vast flood of burning matter, in a state of terrific ebullition, rolling to and fro its fiery and flaming billows.[1]

Most of the islands of the Atlantic Ocean are of volcanic origin. The most northerly of these, the Island of Iceland, is in great part a dreary desert, with many volcanoes, and vast tracts covered with lava, ashes, and volcanic sand. Several of these volcanoes, the highest of which is Mount Hecla, 4500 feet, are still in activity, and fearful eruptions occasionally happen. There are numerous boiling springs in Iceland, which indicate the presence of a constant heat at no great depth below the surface; those in the south part of the island are known as the *Geysers*, the largest of which ejects a column of water, more than 10 feet in diameter to a height of perhaps 100 feet.

The Island of Jan Mayen has the highest and most active volcano known in the arctic regions; the volcanos of Vesuvius and Etna represent the Mediterranean area of disturbance. Further east are the mud volcanoes of the peninsulas separating the Black Sea from the Sea of Azov; and at the south of the Caspian Sea, the extinct volcano of Demavend. The volcanic district of the East Indies, the region of greatest disturbance on the surface of the globe begins in the Gulf of Bengal, extends through the islands of Sumatra and Java, and forms part of the great volcanic belt which surrounds the Pacific Ocean, stretching northwards through the islands of Japan to the peninsula of Kamtchatka, and southwards through the north island of New Zealand to Mount Erebus in the antarctic region. The Island of Java alone has 36 volcanoes, 11 of which are supposed to be now in activity, and near it, on the Island of Sumbawa, is the volcano of Tomboro, whose eruption in 1815 is the most terrible on record. The chain of the Aleutian Islands, which completes the volcanic girdle of the Pacific on the north, has between 40 and 50 volcanic peaks, of which perhaps one-half are in activity.

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[1] Ellis.

There are several high volcanic summits on the Pacific coast of North America, in Aliaska peninsula, and in the table-land of Mexico. In the latter area a violent eruption in 1759 formed the cone of Jorullo, 4114 feet above the sea, which stands on a plain at an elevation of 2890 feet. By the same eruption an area of about 30 square miles was raised several feet above the level of the plain. In Africa, the only volcanic peaks as yet known, are those of Kenia and Kilimanjaro, between the Great Nile Lakes and the eastern coasts, which rise to an estimated height of 20,000 feet, and are thus the highest known points on the continent. In the South Indian Ocean the islands of Bourbon, St Paul and Kerguelen, are of volcanic origin, and the first has a crater which has recently been in activity.

Volcanoes antipodal to each other.

The antipodality, if such a term may be used, of volcanic action, is very remarkable. Besides the two apparent centres, which have been previously called the 'poles,' of earthquake and volcanic disturbance in the East Indies and Central America, being exactly antipodal to each other, the remaining volcanic regions are all nearly so. Thus, the line of South American volcanoes is parallel and nearly antipodal to that of the belt of Eastern Asia; the volcanic region of Mexico is antipodal to that of the South Indian Ocean; the north island of New Zealand to a midway point between the Azores and the Mediterranean volcanoes; and Jan Mayen Island and Iceland to Mount Erebus in the antarctic regions.

The use of Volcanic power

It has been shown that volcanic action, manifesting itself either in shocks of earthquake or in mountains which throw out burning lava, is constantly working over a great part of the surface of our globe, and we now come to inquire into the use to which this force is applied, since no power is exercised on the globe without some final beneficent purpose, though its present action may be disastrous. The main purpose which this action of the subterranean heat of the globe seems to serve is that of maintaining a uniform area of land on the globe, in restoring by upheaval at one part an amount of matter equivalent to that which has been worn down by the action of water in another. In the Notes to Map 14, the method in which this change takes place has been noticed. The areas of present volcanic action are all regions of upheaval, though there are other areas not in the immediate neighbourhood of these in which a very gradual rising has been observed by the former sea margin being left above the present one. Such rising districts are the eastern part of North America at Newfoundland, and the Labrador coasts next to it, the coasts of the north of Baffin Bay, the Azores, and an area under the equator in the Central Atlantic; parts of the west coasts of Europe, of Britain and of Scandinavia both on the side of the Baltic and of the Atlantic, Spitzbergen, and the eastern arctic coasts of Asia, with the Liakov islands; besides the shores of the Indian Ocean in Eastern Africa, at the mouth of the Red Sea, and in Southern Persia; and of the Mediterranean at Asia Minor, and in its western basin.

Areas of Elevation.

Areas of Gradual Subsidence.

The areas of subsidence are always those in which no volcanic action appears, and occupy the central areas of the basins round the margins of which earthquakes are more frequent and the volcanoes are found. Of these areas the greatest occurs in the centre of the great volcanic girdle of the Pacific and in the Indian Ocean, where the numerous islands are believed to be the summits of a gradually submerged continent. The coral islets and reefs which appear in these oceans give a proof of the submergence, since the polypes, which have built them, do not live or begin their labours at a great depth in the ocean, but near the surface on the slope of a coast; now many of these barrier reefs and islets of coral have exceedingly deep water round them at present, and would have the appearance of walls or towers of vast height if the sea were withdrawn. Their foundations have been laid in shallow water, but as the ground on which they stood has very gradually sunk, these works have been slowly added to above, to keep their tops at a level with the sea surface, or in a depth in which the polypes could live. The lowlands of northern Europe next the Baltic, form a sinking area, and the shores of Southern Greenland give evidence of submergence, as do the Deltas of the Nile and of the Amazon.

The Volcanic Heat must affect the surface of the Globe.

The extent to which the subterranean heat of the earth affects the temperature of its surface, and supplements the heat of the sun, is not apparent. But from the increase of the earth's temperature, from the exterior inwards, it follows that some amount of heat must constantly be passing to the surface, and thence into the atmosphere. If it be the case that our earth was originally formed as a melted mass, and that it still retains a great portion of this original heat, it is evident that the earth's crust, from being of the same temperature as the rest of the sphere, has gradually cooled down to its present temperature from the outside inwards, and that less and less of the interior heat penetrates the exterior crust, as the original supply becomes smaller, and the thickness of the more solid part of the shell greater. So it is believed that the temperature of the whole earth is very slowly decreasing from year to year, and this heat can only escape from it by the surface.

The temperature of the land is only affected by the heat of the sun to a very slight depth. The changes of daily temperature due to the sun do not penetrate the soil for more than three feet; and at a depth of forty feet it has been found that the earth's temperature is uniform throughout the year, completely unaffected by outward changes.

Natural History.

GEOGRAPHICAL DISTRIBUTION OF SOME OF THE CHIEF PLANTS AND ANIMALS.

MAPS 27, 28, 29, AND 30.

HAVING seen in the Maps which have preceded this one in the Atlas, the differences which exist on the surface of the globe, in the unequal distribution of land and water, the variations in the height of the land and in the depth of the sea, as well as in the nature of these, caused by different climates and the circulation of atmospheric and ocean currents, it is not surprising to find that the products of the land and sea, or the animals which inhabit them, situated under these varying circumstances, differ also from each other.

Of the causes of variation, both in the quantity and in the nature of the vegetable products of the globe, climate is the greatest, and this also, to a considerable extent, affects the distribution of the different animals, since the area occupied by a part of the animal kingdom is dependent on the extent of the vegetable one, limiting the food of its subjects; and though the carnivorous animals are not thus limited by the distribution of their food, and have a wider range over the globe, still these also, if completely unrestrained, do not naturally pass certain fixed boundaries, which are for the most part marked out by climate lines. Man is the only one of the created beings inhabiting the earth, who may wander over the whole globe and endure its different climates, though, as we shall afterwards see, the dwellers in the different zones have their distinctions also.

The distribution of vegetable and animal life on the globe has been wonderfully adapted to meet the requirements of man in providing him with food and clothing, and aid in the labours of his life, suitable to the zone of which he may find himself an inhabitant. In the tropical regions of the earth, where the external warmth of the sun is very great, mankind are for the most part vegetarian, not requiring animal food for their subsistence, or a warmer clothing than the fibres of plants can supply; and so here we find that the vegetable kingdom has its greatest sway. In the dark Arctic regions, where the cold is greatest, and quantities of heating oil and animal food are required to preserve the warmth of the inhabitants, and give them light during the long winter, and where the warmest clothing is necessary, we find that the vegetable kingdom is at its least, and that great whales, and animals bearing thick and warm furs, provide these necessaries to human life. Again, in the temperate regions between these, in which man is neither compelled by the heat to choose an entirely vegetable diet, nor driven by cold to a warming animal food, but supports life best with a portion of each of these, and in a civilized state makes use of both animal and vegetable tissues for his clothing, these great natural kingdoms are at one and on an equality. Certain animals of these different regions are also specially formed to aid the labours of man. In the hot wastes of the tropics, the camel, 'the ship of the desert,' is capable of sustaining life without food or water for a long period, and alone enables intercourse to be carried on across those vast barriers between the nations. The temperate zone has the horse, and in the Arctic regions the reindeer takes its place, as the main help of man.

I. THE CHIEF USEFUL PLANTS AND GRAINS.

The distribution of vegetable life on the globe is regulated mainly by the influence of climate, or, more particularly, by heat and moisture. These two main influences are combined in greatest quantity at the equatorial regions, and the cold is greatest, though the amount of moisture is not at its least in the Polar regions, so that vegetation is at its greatest luxuriance, and attains its greatest height under the equator, decreasing in the temperate, and becoming stunted and rare, in the Polar regions. The want of moisture, as well as the presence of cold, prevents vegetation, for in all the sandy and waterless deserts of the globe there is no growth, and its absence is only made more apparent by the rich verdure which surrounds any spring or well in the waste. Then again, since the atmosphere receives the greater part of its heat by contact with the heated surface of the earth, the air close to the land is generally warmer than that which is above, till at a certain height this reflected heat has no longer any influence on the atmosphere. At an elevation of 15,000 feet above the sea level at the equator, the freezing point is reached and perpetual snow lies on all parts of the mountains which are above this height; and a line descending on each side, from this height on the mountains at the equator, to the variable isotherm of 32°, or the line of the freezing point, which surrounds the poles, would mark nearly the snow line of all the mountains between the equator and the icy regions of the globe. This change of climate, by elevation in the warmer regions of the globe, brings with it a consequent change in the products of the high and colder land, so that the same differences in the nature of the plants which are observed in proceeding from the equator towards the pole, are seen also in ascending a snowy mountain near the equator.

Plants used for Clothing.

Of the vegetable products which are made use of as clothing for man, *cotton* is the chief, and its use and cultivation extends round the whole of the warmer parts of the world. Cotton was cultivated and manufactured first in the East Indies, and that for a long period before its use was introduced into the other warm countries of the world. The most valued sort is grown in the small islands off the east coast of the United States, between Charleston and Savannah, called 'sea island cotton,' to distinguish it from that which is cultivated on the higher ground in the continent. The cultivation of cotton has a wide extension in the southern parts of North America, east of the great table-land in South America, in Africa, in the 'Tell' slope of the plateau of Barbary, in Egypt, in the fertile lands between the forest regions of the equator and the Sahara, and in the Cape Colony and Natal in the south; the finest sea island cotton can also be grown in Queensland, in Australia, both on the coast slopes and on the higher land in the interior. The district in the north-west of England, which centres in Manchester, is the great cotton manufacturing district of the world, and supplies cloth to all the world.

Next among the useful fibrous plants is *flax*, which also has a wide area of cultivation, and grows equally in cold or warm climates. Its chief region is perhaps that of the northern plain of Europe, in which it is cultivated from Archangel, on the White Sea in the east, through Northern Russia, Germany, and the Netherlands, to England and Ireland; but it is widely grown in Northern India, in Egypt, and in the States of North America. The fibres of *hemp*, though too coarse to use for purposes of clothing, are invaluable as a binding material, for ropes, nets, and cordage; and this plant is cultivated in large districts of Europe, chiefly in North Russia, Germany, and Italy; also in India and China, in the western States of North America, and in Chili, in South America.

Grains used for Food.

Among the grains used as food, the one which sustains the greatest number of men, is *rice*, forming the daily bread of many millions of the inhabitants of the earth in the tropical regions. It grows in all the warmer parts of the globe, from Japan and China in the east, to America, wherever the conditions of moisture and heat are united. In Europe its cultivation is limited by the climate, to the southward of a line from Greece to northern Italy, and across Spain and Portugal. *Wheat* is the king of the cereals of the temperate region. It is cultivated in the warmer parts of the temperate zone, since it requires an average temperature of 55° for four months of the year over Europe and Asia, in Australia, the United States of North America, in Chili, and the La Plata region of South America. It does not grow on the lowlands within the tropics, but may be cultivated on the higher mountain slopes there, or on islands at a moderate elevation.

Maize is the corn of America, which grows both in the tropical and in the warmer parts of the temperate zones, but has now become a staple of food in Southern Europe, and has extended across Asia to China and the Indian archipelago, and to the negro states of Africa. *Rye* is specially the bread grain of the German part of the plain of Europe. *Oats* and *barley* are the two grains which can flourish in the coldest parts of the temperate zone, and the latter may grow in as high a latitude as 70° N. on the west coast of Europe, or at an elevation of 13,000 feet in the Asiatic table-land. Neither of these grains are much used as bread, the former only in Scotland; but oats form the main food of the horse in the temperate zone, and barley is in great part used in malting.

Roots used for Food.

Of the roots which may be used as food for man, the *potato* is the best, and has the widest cultivation both within the temperate and colder countries. Its native place is South America, and was found in cultivation on the highlands of Chili and Peru, but it has now become an indispensable article of food in both hemispheres, and is cultivated in all the continents, almost to the polar circle in Europe; in North America, South Africa, Australia, and New Zealand.

Cassava bread is the starchy root of a shrub about six feet high, which is extensively cultivated in the tropics, and in some parts is the main source of subsistence. Its chief areas are Brazil and the

West Indies, in the New World, and the Gaboon region of Africa and the East Indies, in the Old. The root is poisonous in its natural state, but the narcotic may be either washed or roasted out of it. Its meal is known as Tapioca in the markets of Europe.

Arrow Root is the tuber of the maranta. which grows in most of the warm and damp parts of the tropical regions; in the East Indies and in South America; and the West India Islands, more specially in Jamaica.

Fruits used for Food.

The *Banana* or *Plantain* is one of the most important fruits of the hot countries of the globe. The gigantic herb, for it is not a tree, bears a great quantity of fruit, is easily cultivated, and is so nutritious, that 'the same extent of ground which, in wheat, would maintain only two persons, under banana will yield sustenance to fifty.'[1] In the tropics it grows up to a height of from 4000 to 5000 feet above the sea. and in the lowlands may extend to the 30th parallel.

The *Bread Fruit* tree is also confined to the hot regions of the globe, and has not such an extensive range as the banana. It is found over the whole of the East Indian archipelago. and in the islands of the Pacific, and has also been introduced into South America and the Antilles, and into Mauritius and Bourbon, in the Indian Ocean. The tree is covered with fruit for eight or nine months in the year, and it is said that three trees are sufficient to supply a man with pleasant food for the whole of a year.

The *Date Palm* is one of the most productive plants of the tropical regions. It is native in Mesopotamia, and extends round the outer slopes of Arabia, and along the north of Africa, inland from the Mediterranean, and on the west as far as Senegal; and eastwards to the mouth of the Indus, in Northern India. An idea of the productiveness of these palms may be made from the fact, that as many as 20,000 dates may be gathered from one tree in a year. The queen of all the palms is the one which bears the *cocoa-nut*, a slender graceful tree, every part of which is useful to man. Ceylon, Southern India, and the East Indies, are the special area of this palm, but it has been introduced into all the suitable parts of the tropical world. The milk of the cocoa-nut, when it is still unripe, affords a cooling drink; and when ripe, the kernel is a favourite food. Then an oil may be pressed from the kernel, and this has become a great article of commerce; and the tough brown fibres which enclose the nut is 'coir,' valuable in commerce, and used as hemp in making cordage. The hard shell of the nut provides natural dishes; the trunk affords masts or beams, and the roots, besides being a medicine for fevers, may be woven into baskets; and the stem of the living tree, if pierced, affords the refreshing palm wine.

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[1] Balfour's 'Manual of Botany.'

The *Orange* has its home in Southern China and in parts of India, and has spread over Palestine, Egypt, the north coasts of Africa, to Malta and Sicily, and was brought by the Moors to Spain. Large quantities are exported from the Azores.

Vines grow wild to the south-east of the Caspian Sea, and their native area lies probably between Asia Minor and Persia. The range of the vine is now over the whole of the southern temperate part of Asia, and the greater part of its tropical region; Southern Europe, and the Mediterranean slopes of Africa; the central islands of the Atlantic, in the south of North America to California; in Southern Brazil, the La Plata lands, and Chili and Peru, in South America; as well as on the outer slopes of South Africa.

The original area of the *Olive* is North Africa, Syria, Arabia, and Persia, and it has extended to the southern parts of Europe next the Mediterranean basin, and has been introduced into Mexico and South California. The oil of the olive is one of the most extensively used for food as well as for manufactures.

Plants used in making drinks.

Among the vegetables which are used in the preparation of drinks, *Tea* is the most important, and gives rise to a large share of the world's traffic.

The area of its cultivation extends, in Eastern Asia, from Japan to Assam, in India, its special central region being the plain of China. It is universally used in China; but it is exported thence to all parts of the world, and is brought to Europe, either by sailing vessels round the Cape of Good Hope, or by caravans across Asia to Russia.

Coffee is native in Abyssinia, but has been transferred to Arabia, where it is now most extensively cultivated. The coffee tree is from 6 to 12 feet high, and it is remarkable that in almost all seasons of the year, blossoms, and green, and ripe fruit may be seen on the same tree. When the blossom falls off, there springs in its room a small fruit, green at first, but which becomes red as it ripens, and is not unlike a large cherry, and is good to eat. Under the flesh of this, instead of a stone, is found the bean or berry called coffee. The berry is then very soft, but as the cherry ripens the berry in the inside grows harder, and the cherry turns a dark brown pod. The berry is now solid, of a clear transparent green colour. Each shell contains one berry, which splits into two equal parts. When the fruit is sufficiently ripe, the pods are shaken from the tree, the husk is used in Arabia, and the berries are exported. Coffee was introduced by the Dutch into the East Indies; and its cultivation has now spread over these, and has found its way to the West Indies and to South America.

Gums and Juices.

Among the many gums which are derived from the stems of trees, *Gum Arabic* is one of the best known. It flows from the cracks in several kinds of acacias, which are found in Arabia, but the main area of its production is in northern Africa, from Egypt to Senegal.

Gutta Percha is chiefly brought from the East Indies, China, and Further India, besides Ceylon and Malabar.

Caoutchouc, or *India Rubber*, is derived chiefly from trees which grow in the Amazon basin in South America.

The *Sugar Cane* belongs originally to Eastern Asia, from northern India to the East Indian archipelago, South China, and many of the islands of the Pacific. From this it has been transported over Asia and to Madeira, and the tropical parts of America, which have become its second home. From its saccharine juice the most of our sugar of commerce is made.

Useful trees.

The *Teak* tree supplants the oak in the warmer countries of the world, and is put to the same uses in the lands in which it grows. Its area is Southern India, especially on the Malabar coast, and it is common on the eastern shores of the Gulf of Bengal, in Tenasserim. This wood is extensively used for ship-building purposes. *Ebony*, the valuable black wood, is found in its finest condition in Madagascar and Mauritius, but grows also in India and Cochin China. *Mahogany* has its chief growth in Honduras, and in the other states of Central America, where it is the slow growing 'king of the woods,' but is found in Cuba, in the West Indies, in Cayenne, in South America, and in Senegal, in Africa. The *Cork oak*, besides providing stoppers for all kinds of bottles and casks, is indispensable in the process of tanning. This tree is found in greatest numbers in Spain, Italy, especially the Island of Sardinia, in Southern France, and Algeria. It is only in its twenty-fifth year that this tree affords good workable material.

Among the luxuries of the vegetable kingdom may be named *Tobacco*. This is the dried leaf of various kinds of plants of the species *Nicotiana* (so called from Nicot, the Spanish ambassador, who introduced tobacco into France in 1560). It was discovered by Columbus in 1492 in the Island of Cuba. Its cultivation afterwards spread to Virginia, and over the West Indies, and now different sorts of tobacco are grown in the north and west of India, in Java, and at Manilla in the Philippine Islands, in Algeria, the Cape of Good Hope, Turkey, Russia, Hungary, and Portugal. *Opium* is derived from the head of the white poppy, which grows in the warmer parts of Asia and Europe. It is specially used as a stimulant by the Chinese, but is also the bane of the peoples from Turkey to Japan.

Luxuries.

Among the spices, there is none so extensively used as *Pepper.* Its native-place is the Malabar coast of India, where it grows wild; but it has spread to Further India and the East Indies. Cayenne pepper grows in the West Indies, in Central America, and in Guiana in South America. The cultivation of the *Clove* tree was, at one time, confined by the Dutch to a few of the Moluccas, or Spice Islands, where it has its home; but it has now been transplanted to tropical America and Africa.

II. DISTRIBUTION OF SOME OF THE CHIEF ANIMALS.

The distribution of animals, like that of plants, is mainly dependent upon climate, which varies generally either according to distance from the equator or according to elevation. The same climate lines which we have seen marking out the different floras, form also the approximate limits of the distribution of many of the animals of the globe. To illustrate this distribution, it is not necessary, nor does space here allow us to enter into a complete exposition of the area occupied by each of the members of every class into which the animal kingdom has been divided, of mammals, birds, reptiles, fishes, and insects, but, by examining the distribution of a few of the chief mammals in the different zones, we shall arrive at the desired result; and we shall see that though precisely the same species of animal does not always extend in the same zone in both great continents of the Old and New World, yet a variety of the same species, or an animal of a similar nature is found to correspond in the similarly situated areas of each continent.

A main line of distinction separates the land mammals in the nature of their food—one large class is herbivorous, or subsists entirely on vegetable food; another large division is carnivorous, and preys upon the former class. Both are limited, to a great extent, by climate, and we shall notice that particular herbivorous animals are usually found together with special carnivorous animals in the different zones.

Polar Regions.

To begin with the Polar zones, the characteristic land animal of the arctic region is the white or *Polar bear*, found in all the arctic coasts, and occasionally carried southward on icebergs and drift ice.

The *musk ox* is a native of arctic America, but does not appear in Asia. The southern limits of the *reindeer* in Europe, and Asia, and America, agree well with the general climate limits of the arctic faunas, excepting where they extend down into Scandinavia.

The *right whales* are the great representative mammals of the Polar Seas, and are sometimes nearly conterminous with the sperm whales which inhabit the warmer waters. The average areas occupied by these two whales are shown on the map according to the limits of their appearance laid down in Maury's charts. The right whale—so called to distinguish it as the useful whale, from the 'Finner,' a larger member of the species, which has a dorsal fin but little oil or whalebone—has its habitat in the icy regions, but may be found in the Atlantic, as far south as a line joining Newfoundland to Spain, and in the Pacific north of a curving line from the south of Japan to Vancouver Island. In the South Atlantic it advances from the Antarctic regions to beyond the latitude of Cape Colony and the La Plata; in the Indian Ocean to a line joining the Cape with the south coast of Australia; and in the Pacific it is found to the north of New Zealand in the west of the ocean, but it keeps to the south of the desolate region of the sea which lies between New Zealand and South America, in which mariners report 'few signs of life in sea or air.'

The *seal* is also an animal which abounds most in the colder parts of the earth, though it extends also into the temperate, and in some parts even into the tropical regions. The *earless* seal is generally confined to the northern, and the *eared* seal to the southern, hemisphere. Earless seals inhabit the Arctic American coasts from the peninsula of Aliaska all round the north to the 40th parallel on the east coast, the shores of Greenland, of Iceland, and of northern Europe, and Asia, from the Bay of Biscay in France, to the south of Japan on the east. Isolated areas in which the same species is found are Jamaica and the Antilles in the West Indies, and the east coast of Patagonia in South America, besides the head of the Adriatic, the Caspian Sea, and the great fresh-water sea of Lake Baikal in

Siberia. Eared seals are found on both sides of the peninsula of Aliaska, and live together with the earless variety in the Aleutian Islands, on the outer coasts of Kamtchatka and of Japan. In the southern hemisphere their distribution is in the temperate part of South Africa at Cape Colony, on the coasts of Australia, excepting the northern next Torres Strait, and round the Moluccas Islands in the tropical region.

The *walrus* is another inhabitant of the icy regions, but with a smaller range, in Behring Strait, the north of Hudson Bay, and on the coasts of Baffin Bay; in Spitzbergen and Nova'a Zemlia, and on the coasts of Arctic Asia, between the 40th and 90th meridians.

Temperate Zones.

The temperate zone is the most generally cultivated of the globe, and it is here that the domesticated animals are found in greatest numbers; and the carnivorous animals, driven out by the appliances of civilization, are least abundant. The *wolf* seems to be the most widely distributed of the carnivora of the temperate zone. There are two varieties of it, the American and the Asiatic; the former extends over the whole of the less populated parts of North America from the Gulf of Mexico to the limits of the forests in the north, and the latter ranges over the whole of Europe, excepting the British Isles, Spain, and Prussia, in which countries it has been exterminated, and in the Arctic regions of Asia to the northern limits of the Siberian forest, and southward in Western Asia to the borders of the tropical regions, but remaining outside of the Chinese Empire in the east.

Black and brown *bears* are found in the whole of temperate North America, in the Andes of South America, and are scattered in Europe and Asia. Originally the brown bear was also a native of Britain. *Grizzly bears*, the most formidable animals of the northern part of the new world, are confined to the western plateau of North America, and extend as far as 61° N. latitude.

The *red deer* is found in the whole of Europe, and in a central belt of Asia as far as Lake Baikal and the Lena River. This deer is also found in a natural state in the Highlands of Scotland, the greater part of which country is preserved as a 'forest' for this animal. At a certain season of the year it is 'stalked,' and the stags are shot down. *Roe* deer extend over the whole of Europe, but are more plentiful in the south.

The *beaver*, one of the most important of the rodents (or gnawing animals), formerly inhabited the whole of Europe and Western Asia, but this variety is now confined to the inland central part of Europe. The Canadian beaver was formerly very numerous in the temperate forest region of North America, but became almost extirpated at the time when there was a great demand for its fur, but now that this has been replaced in hat-making by the use of silk, the beaver is again recovering its numbers.

The *oposssum*, the best known of the new world marsupial (or pouched) animals, has a wide range over a great part of the temperate region of North and South America, and over the whole of the tropical area. It is probably most abundant in Brazil. The chief of the old world marsupials, the *kangaroo*, is found in the whole of the explored parts of Australia, and in New Guinea. Different varieties of the kangaroo are adapted to the desert regions, and to the scrub or bush of Australia.

The desert regions of the globe extend, as we have seen, chiefly in the margins of the tropics, or in parts of the temperate regions above these. The *camel*, perhaps the oldest species of mammal now in existence, seems to have been specially formed to live in the deserts, and without its aid these wastes of the world would be impassable. The area occupied by these animals is, therefore, the Sahara of Africa, Arabia, Persia, and Tibet. The single humped variety, called the *dromedary*, is found in South-Western Asia and in Africa; the two-humped, or Bactrian camel, lives in the colder part of the area, in Asia as far as the confines of China. The camel does not appear in the new world, but the *llama* takes its place here, and occupies the elevated Andes region of South America, where it is used as a beast of burden, and we have before noticed that the llama is specially abundant in the desert region of the Puna.

The *bison* is found in the treeless region of central North America; the *Cape buffalo* in the south of Africa on the southern borders of the tropical region; and the *Indian buffalo* has spread along the northern verge of the tropics, from North Africa to China. The *yak* occupies the high Asiatic plateau.

The *tiger*, second in power of the carnivorous animals, belongs equally to the temperate and to the tropical region, and does not seem to require a warm climate, since it lives in elevated situations even in the temperate zone. Its area in South-Eastern Asia, is marked out by a line from Persia to the Amur River on the north-east, passing southward of Lake Baikal, and including Sumatra and Java on the south, but not Ceylon or Borneo.

Leopards extend over Africa, Arabia, Asia Minor, Southern

Persia, India, and Further India, and the south of China, as well as in Sumatra, Borneo, and Java.

Tropical Zone.

The *lion*, the king of the carnivorous animals, has its main distribution in Africa, and more sparingly in Western India. It is remarkable that the tiger only appears where the lion dies out. The *hyæna* occupies nearly the same distribution as the lion, in different varieties. In South Africa it is brown, then it is spotted in the Sahara, and striped in the rest of Africa and in Asia. The carnivora corresponding to these in the tropical parts of the new world are: the *puma*, which is found over the whole of the less cultivated parts of the continent, southward of a line from Vancouver Island to the south-east coast of North America; and the *jaguar* in Mexico, Central America, and the tropical parts of South America.

Among the great herbivorous animals of the tropical region are: the *hippopotamus*, found in the great rivers of Africa, the Nile, Niger, and Senegal, but excluded by its nature from the Sahara, and from Cape Colony on the south.

The *tapir*, another of the thick-skinned animals of the tropics, has a large range in South America: from the La Plata to Central America, excepting on the Pacific slope. An Indian variety occupies Cochin-China, the Malay peninsula, and Sumatra. The *rhinoceros* has its area in the south of Africa beyond the Sahara, in Southern India and Ceylon, in Further India and Sumatra. The *elephant* has the same present extent as the rhinoceros, but the remains of the mammoth, the fossil elephant, are found in the whole of North America, in the Andes of South America, Europe, excepting the north-western parts, and over the whole of the Siberian plain to the east cape of Asia.

The *giraffe* inhabits the southern parts of tropical Africa, avoiding the highlands. *Antelopes* are most numerous in South Africa, but extend into Southern Arabia, India, and Further India, and are also found in Borneo and Sumatra. An American variety is found in the western states of North America, and in Mexico.

Monkeys are widely distributed in the tropical parts of the globe. In America their area is the whole of the tropical forest region, from the La Plata to Central America. They inhabit the whole of tropical Africa, excepting the deserts, besides Southern Arabia, India, and Further India, to the middle of China; and in the East Indies, the islands of Sumatra, Borneo, the Philippines, Java, and Japan. American monkeys are distinguished from those of the old world,

in having prehensile tails, and in not having cheek pouches, these belonging to the old world monkeys only. *Baboons* have their area in Africa, south of the Sahara, and in the Celebes and the Philippines. *Anthropoid apes*, or the animals which approach most nearly in outward form to mankind, and in their sometimes erect gait, are found in two differing but connected species on the opposite sides of the Indian Ocean, furnishing thus an illustration in favour of the former existence of a now submerged Indo-African continent. In Guinea the anthropoid apes are the *gorilla* and *chimpanzee;* and in Borneo and Sumatra the *orang outang*. The *gibbons* of the east of the Bay of Bengal, and in the East Indies, are also anthropoid.

There are two opinions regarding the origin of the different kinds of animals, which we now find on the globe. The first, the older belief, is that each species of animal in the land and water has been produced as an independent creation; the other, and more recent, termed the Darwinian theory, from its author, is that of the origin of species from one original stock by development, by long continued gradual variation and selection, through the struggle for life. The truth, perhaps, lies between these two extremes: for though it is impossible to believe that all the forms of animal life on the globe have developed from one original creature in the sea or in the land, yet the great variations in form observed between different members of families, which have obviously been derived from one stock, when introduced into new conditions of life, makes it almost equally improbable that every different form of animal life has had a special creation.

VARIETIES OF MAN.

MAP 31.

IN the map showing the geographical distribution of the 'Varieties of Man' in the Atlas, the three primary divisions of the human race as distinguished by Latham are indicated, and the following notes are based chiefly on his work.[1]

The varieties of the human species have been arranged *philologically*, that is, according to language, and the relation between the different words which constitute sentences; and also *physically*, according to anatomical structure, chiefly by the differences in the formation of the skull. The former is the more important and valuable element of classification, since nothing but imitation determines the use of similar combinations of articulate sounds in language, whereas similar conditions of life tend to develop a similar physical conformation. Three individual specimens of the human race, which would exhibit three of the most important differences would be: a Mongolian from Central Asia; a Negro from the Delta of the Niger; and a European from France, Germany, or England. 'The Mongolian's face would be broad and flat, with the cheek-bones prominent. The breadth of the head, from side to side, would be nearly equal to its length from front to back; the nose would be flat, and almost certainly neither arched nor aquiline; the eyes would be drawn up at their outer angle, the skin would be of a yellowish-brown, the hair straight, the beard scanty, and the stature under-sized. The negro, besides his black complexion and crisp hair, would exhibit a greater depth of head, measuring from before backwards, and the upper jaw would be much more projecting. The European would be characterised by negative rather than positive qualities. His face would be less broad, and his head would have greater depth in proportion

The Extremes of Variety.

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[1] 'The Natural History of the Varieties of Man.' By Robert Gordon Latham, M.D., F.R.S. 1850.

to its breadth, than would be the case with the Mongol. As compared with the African, he would differ most in the parts between the nose and chin. The mouth of the negro, instead of lying *under* the nose and forehead, projects forwards in a slightly elongated shape, so as, in extreme cases, to be a muzzle rather than a mouth; the effect of which is to throw the upper part of the face and head *behind* the jaw. In the European profile, on the other hand, the general direction is vertical. The upper jaw does not project, and the forehead does not retire; so that the forehead, nose, and mouth are, comparatively speaking, nearly in the same line.'

These external differences of outline are produced by the differences of the skull and the bony parts of the face; and as, in addition to this, the skull is the receptacle of the brain, and the brain is the organ wherein the human species most differs from others, anatomists have been in the habit of determining the varieties of the human race by the difference in the conformation of their skulls.

Three Primary Divisions.

The number of the primary divisions determined from these elements is limited by Latham to the three which display these extremes of difference: the Mongolian, the African, and the European,[1]—thus simplifying the former more numerous divisions.

The distribution of the Mongolian division is in Asia, Polynesia, and America; of the African, in Africa and Arabia; of the European, in Europe and Persia, and in the European colonies.

Asiatic Mongolians.

The language of the Chinese, Tibetans, and Indo-Chinese, including the Burmese and Siamese, represents the earliest known stage of human speech, having changed more slowly than the other tongues of the world, the separate words consisting generally of a single syllable; and the Chinese is the most homogeneous and dense population[2] of the globe, having one language and one type of feature. The *Chinese* have a softened Mongolian conformation of feature, a yellow brown complexion, a broad face, with narrow and oblique eyes, and scanty beard, lank black hair, and a stature below that of Europeans.

The typical Mongolian physical conformation is found in the northern parts of the Chinese Empire, in the greater part of Siberia, in Mongolia, Tartary, Eastern Turkestan, Asia Minor, Turkey, Hungary, Finland, Esthonia, and Lapland; and the language of the inhabitants of this area is not mono-syllabic. This essentially Mongolian area includes the *Mongolians* and *Kalmucks*; and the *Turks*, extending from Southern Europe far into Central Asia, of whom the *Yakuts* of the Lena are an isolated portion, but possessing a language so similar, that 'the Yakut of the Icy Sea is said to be intelligible to the Turks of Central Asia, and even of Constantinople.' The inhabitants of the Caucasus, from the evidence of their language, are claimed by Latham as modified Mongolians. This includes the *Circassians*, whose physical conformation has been considered closely akin to that of the highest type of European, and indeed has been taken as the typical conformation of the Indo-European division. The *Samoeids* of north-western Siberia are undersized Mongolians, and approach the Eskimo or Greenlander in appearance.

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[1] Mongolidæ, Atlantidæ, and Japetidæ.

[2] See Tables at the conclusion.

Oceanic Mongolians.

Oceanic Mongolians occupy every inhabited spot of land, from Madagascar on the west to Easter Island on the American side of the Pacific; and from Formosa on the north to New Zealand southwards, as one and the same race. One class of these islanders is *black-skinned*, comparable with the African negro, and has for its area New Guinea or Papua, Australia, Tasmania, New Ireland, and the islands between it and New Caledonia. The second class is *yellow*, *olive*, *or brown*, approaching the true Mongol type, and these occupy Sumatra, Borneo, Java, the Moluccas, the Philippines, and all the islands of the Pacific not enumerated as inhabited by the black-skinned division. The chief characteristics of the black class are a rough skin, crisp and woolly black hair, and a medium stature, in Australia presenting perhaps the lowest form of humanity; and of the brown or olive class, the face is flat, the nose short, the eyes and hair black and straight, and the stature short in the western part of the area; and the stature taller, the colour more approaching that of the European, the hair waved or curling, and the nose frequently aquiline, in the eastern or Polynesian part of the area.

Under the heading of 'Peninsular Mongolians,' the *Koreans*, *Japanese*, and *Kamtchatkans*, have been classed together by Latham, for the reaaon that their languages agree in the general fact of being more closely akin to those of America than any other, or form a link between those of Asia and America. The Koreans are described as strong and vigorous men, with Mongolian features of a reddish-yellow complexion; the Japanese, of middle size, active and easy in their motions; whilst the Kamtchatkans are undersized Mongolians, with sunken eyes and depressed noses.

The Eskimo the connecting Link.

The *Eskimos*, occupying parts of Greenland and Arctic America, are also found on the Asiatic side, and so form the only family common to the old and new worlds; and if the doctrine of the unity of the human race is to be adopted, then the new world must have been peopled through their means, across the strait which separates the continents; but the physical differences between the American Indian and the Eskimo, as well as the difficulties presented by the Eskimo language, militates strongly against this theory, though no distinct line can be drawn between the Eskimo and the Indian in the south, since they merge gradually into one another. Physically, the Eskimo is a stunted Mongolian, but the grammatical structure of his language is American, and this peculiarity of the American languages, in their agreeing grammatically one with another, though their vocabularies differ, provides an evidence of the unity of all the American populations.

American Mongolians.

The *Athabaskans*, consisting of various tribes of migratory hunting Indians, extend from Hudson Bay to the west coast of America, bordering on and conterminous with the Eskimo on the north. The *Algonkins*, a collective name for the Indians distributed in the space between the Rocky Mountains and Newfoundland, and the Iroquois of the American lake region, 'exhibit,' says Latham, 'in the most typical form, the characteristics of the North American Indians, and are the two families upon which the current notions respecting the physiognomy, habits, and moral and intellectual powers of the so-called Red race, are chiefly founded.' The heads of the American Indians approach the Mongol type; the skin is of a deep red copper colour; their form symmetrical; they are tall, of active and daring habits, combined with great vigilance and observation. The *Sioux* is the third great division of the North American Indians, and comprises the tribes of the interior, between the Mississippi and the Rocky Mountains.

Paduca is the name given to an imperfectly known division of the Indians, who occupy the central part of the American table-land, from the Pacific to the Gulf of Mexico.

The peculiarities of the *Mexicans*, distinguishing them from the Indians of the north, may be accounted for by the remarkable nature of the country they inhabit, in the contiguity of the two oceans, the range of temperature arising from the differences of altitude, the consequent variety of its products, the absence of the condition of a hunter state, and the abundance of minerals.

The language of the Indians of the *Moskito* coast is peculiar, and they have a considerable intermixture of negro blood.

In South America, the *Quichua* tribe of Indians extends discontinuously on the western side of the continent from the equator to 28° S. latitude, and beyond these the stock of the *Chilians* or *Patagonians* occupy the southern angle of the continent. The great stature of the Patagonians has been repeatedly noticed by travellers, but the natives of Tierra del Fuego are rather undersized, and are ill-fed fish eaters, like the Eskimo.

The *Caribs*, the great family of Guiana, extending from the mouth of the Amazon round the north of the continent, were one of the first tribes known to Europeans; their language is the single one of this large area.

The *Maypure*, conterminous with the Caribs, occupy the middle part of the banks of the Orinoco, the Amazon, and Rio Negro.

Brazilians. Tupi, or Guarani, the second great stock of the eastern side of South America, have the whole area from the Amazon to the La Plata. The *Moxos* Indians occupy the upper part of the watershed of the Amazon between Brazil and the Andes; and the *Chiquitos*, the opposite water-shed of the La Plata. El Gran Chaco, in the Argentine Republic, is scantily peopled by nomadic tribes.

Africans.

The African type is exhibited in its most remarkable form in the negroes of Western Africa, between the Senegal and Niger Rivers; but Negroland extends from this eastwards as far as the White Nile, and southwards, in the centre of the continent, to include the Balonda negroes of Livingstone, at the head-waters of the Zambezi. The chief divisions of the negroes are:—in the region of the Lower Senegal, the *Jalofs*, tall, well made men, with the nose less depressed, and the lips less prominent, than the more typical tribes: the *Mandingoes*, extending from near Cape Verd Island to near the Lower Niger, tall and black-skinned; the lighter coloured *Fellatahs*, or Fulahs, occupying discontinuous areas from the west coast across the States of Soudan, ruling its most powerful kingdoms, and still encroaching. They differ in appearance considerably from the typical negro, so much that those of the Gambia are called *red* Fulahs. Their religion is Mohammedan, and their origin is a matter of doubt. The *Denkas*, on the Nile, the most easterly negroes of Central Africa, are a tall race of a generally dark brown colour, with thick lips, and more prominent nose than the typical negro. The *Niam-niam* tribe of the west of the lake region of the Upper Nile, the fabled half men half dogs, are described by the Marquis Antinori,[1] as men of powerful, regular and beautiful, form, with a stately carriage, bronze coloured skin, and long sleek hair and beard, whose characteristics approach the Galla, and probably identify them with the Fellatah, the distinguished and dominating race found on the other side of the continent.

In South Africa, the *Kaffirs*, a modified negro race, tall, black or dark-brown, with projecting cheek bones, and tapering forehead and chin, occupy the eastern part of the continent, and the Hottentots the western side. The dividing line between these races extends from the south-east corner of Africa, across the Kalahari Desert.

The *Bechuanas* are an inner division of the Kaffirs, whilst the Kaffirs proper are next the east coast.

The *Hottentots* are of low stature, with slight limbs, brown or yellow colour, with prominent cheek-bones, depressed nose, and tufted hair.

The *Gallas* of Eastern Africa, on the south-east of Abyssinia, are modified negroes, of a colour varying from deep black to brownish yellow, tall, with nose straight or arched, and the brow vaulted, approaching the Arab conformation. The race is eminently encroaching.

In the valley of the Nile, the *Nubians* are the transition stage between the negro and the Egyptian. In physical appearance they are slender, middle-sized, and of a dark brown colour, with frizzled but not woolly hair, and a pointed nose.

The *Copts* of the delta of the Nile, are the ancient Egyptians, since the present dominant race in Egypt is Arab, tall. with a colour from yellow to dark brown, projecting cheek-bones, thick lips, and depressed nose.

Arabs of the peninsula have a brown complexion, oval face, and vaulted forehead; straight or aquiline nose, thin lips, and wavy or curled hair. In those of Africa the colour is sometimes nearly black.

The table-land of Abyssinia, or Ethiopia, is encroached upon by the Gallas in the south, and by the negroes on the west. The aboriginal Abyssinian Christians are considered to have immigrated from Asia by the Isthmus of Suez, since their characteristics are allied to those of the Syrians.

West of the Nile, the inhabitants of Northern Africa are sometimes a modification of the negro, sometimes of the Arab; along the north side of the continent the Africans have the general name of *Berbers*. The language of the *Moors*, the furthest west, is a mixed dialect of Arabic, and the men are of middle size, with a colour varying from yellow to black. *Tuareks*, a light brown, or red race, occupy the central part of North Africa. Conterminously with the negro states of the centre, and east of these are the *Tebu*, whose language, as examined by Dr Barth, afterwards confirmed by Rohlf,[1] unite them with the negroes of Central Soudan, though their light brown colour would connect them with the Berbers.

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[1] In Petermann's Mittheilungen xi. 1868.

Indo-Europeans.

Indo-Europeans are divided by Latham into the *Celtic*, or Western division, occupying the present areas of Brittany, Wales, the Highlands of Scotland, the Isle of Man, and Ireland (whose line of population was, from the nearest parts of the French coast to England, from England to Scotland, and thence to Ireland), distinguished by a light complexion, a lengthened head from front to back, prominent cheek-bones, and sandy or red hair; and the *Indo-Germanic*, in Europe and Persia, the former country including the *Gothic* of Central and Western Europe, whose original area was Western Germany, characterised by blue eyes, flaxen hair, and a ruddy complexion; the *Sarmatians* of Eastern Europe, with heads extending in breadth rather than in length, and merging into the Mongolian; and the *Mediterranean* Indo-Germans, with long heads in the direction from front to back, dark hair, eyes, and complexion, and a slender frame. The *Persian*, or Iranian Indo-Germans, occupy Kurdistan, Persia, Beloochistan, and Afghanistan, and are of varied complexion, fair in the mountain regions, and dark in the deserts, with regular and prominent features.

More recently[2] the opinion has been advanced that there are only two great divisions of mankind equal in value, and marked by characteristics of equal importance; these may be called the *blacks* and the *whites*, the extremes being the negro and the European, since the Mongolian and European seem to merge into one another. The inhabitants of Northern Africa are more closely united to the white race, and the black coloured division of the 'Oceanic Mongolians' before noticed, have close physical affinities with the negroes of Southern Africa, so that the black race occupies the greater part of the land in the Southern Hemisphere; and it is conjectured that the white race are derived from the black, since the older land is in the Southern Hemisphere; this theory agrees with the order of progress, a more elevated species springing from and supplanting an older and less gifted race.

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[1] Journey across Africa, in Petermann's Mittheilungen x. 1867.

[2] The 'Geographical Distribution of Mammals.' By Andrew Murray. London 1868.

(2.)—DISTRIBUTION OF POPULATION OVER THE GLOBE.

An examination of the distribution of the human race according to numbers, follows not inappropriately that of the distribution according to variety of race. This distribution is naturally limited to the habitable parts of the globe, and we have seen, in the Notes on the Hemispheres, Maps 3 and 4, that a great proportion of the earth's surface is either desert or covered with forest; and again, that a considerable part of it is at a high elevation above the sea. The unproductive parts of the earth, the icy arctic zone and the torrid zone, are avoided, the forests are a barrier to the extension of population, since the ground must be cleared before it can be cultivated, and the mountain regions, from the difficulty of access to them, are seldom thickly peopled. It is in the more open and fertile plains or undulating land, and in the valleys next the greater rivers, near the sea coasts or in the larger islands, that population settles and extends; for in these the labours of agriculture are lightened, the means of subsistence are readily procured, and intercourse is easy either by land or water. To give an accurate view of the density of population on the earth, the numbers of inhabitants in small areas of equal extent should be obtained; but since the method of enumeration hitherto adopted has been that of a census of each political state or division, whatever its extent or the irregularity of its boundaries, we are obliged to rest satisfied with these, which at best give only a general idea of the distribution of peoples; for a large area may be densely inhabited in one part and deserted in another. The following tables show the present area and population of each state throughout the world, arranged in the order of the density of their population, or the average number to a square mile, under the great divisions of the globe. In a general view of these tables, in connection with the previous subject, we observe that in Europe the Indo-European race has by far the greatest general density of population over its main area on the globe, having an average of 75 to an English square mile. Next follows the African race, as far as yet known or

The Circumstances which determine the Distribution of Population.

estimated, with an average of 16 to a square mile; and lastly, the Mongolians, in their widest distribution over Asia and America, with an average of only 14 to a square mile. This last variety of man, however, presents the greatest contrasts in distribution, being a dense population in its central area of Eastern Asia, and decreasing in numbers in its extension to the scattered population of Australasia, which has on an average only 1 to a square mile.

Europe. In Europe it is observed that the most dense population of any state in the world occurs in the lowland of the west coast in Belgium, being there upwards of 400 to a square mile, but this density is perhaps exceeded in an equal area of some parts of China. The British Isles, taken as a whole, come third on the list in the density of their population; but if England be considered alone, it would rise to the second position in Europe, and Scotland would fall to an average place in the table. The lowest in the population scale in Europe is Iceland, with only 2 to a square mile, and the density of population in Europe decreases generally to east and northward.

Asia. In Asia, the greatest density of population is in China, which vast area, of more than one-and-a-half million of square miles, has an average of nearly 300 to every square mile: this density must obviously be variable, less in the more mountainous regions of the west or interior of China, and greater in the plains next the coast, so that the most extendedly dense population in the world is to be looked for here. Japan follows closely, and next to it is India, but with a reduction to half the density. Contrary to Europe, the population in Asia becomes more scattered to north and westward.

Oceania. In Australia and Polynesia, the smaller islands of the Pacific are observed to have a much greater density of population than the larger. The least peopled habitable area of the globe is Australia, whose population is almost confined to the south-east corner, and the vast area of North Australia, has only an average of one man to every 40 square miles.

America. The most populous of the states of North America is Massachussets, which is comparable, in this respect, with Switzerland or Austria. The highest densities are in the Eastern United States, in Canada, and in Mexico, whilst the population decreases rapidly to north and westward towards the arctic regions, so that in British North America there is only an average of one man to every square mile; and in Greenland, perhaps 70 square miles to each inhabitant. Chile has the greatest population of South America, but the density is so small as to be comparable to that of Tibet or Afghanistan. Next it comes Paraguay in the east side, and then the United States of Columbia in the north. Guiana is very thinly inhabited, the population being almost confined to the coasts; and in Patagonia, the southern extremity of the continent, there are 12 square miles to each inhabitant.

Africa.

In Africa, the Mohammedan states of Central Soudan would appear, from their estimated population, to have the greatest density, somewhat less than the average of Europe. Cape Colony is very thinly peopled, and may be compared in this respect with Tasmania or New Zealand. The most scattered population in Africa occurs in the Sahara, or in the Portuguese territory of the east coast.

DENSITY OF POPULATION.

(The areas and populations given in Behm's Jahrbuch have been used as a basis for these tables).

I.—EUROPEAN STATES.	*Area in sq. Miles.*	*Population.*	*No to a sq. m.*
Belgium,	11,374	(1865) 4,984,451	438
Netherlands and Luxembourg,	13,670	(1866) 3,759,239	275
Great Britain and Ireland,[1]	122,511	(1866) 30,078,851	245
Italy and Papal States,	114,380	(1863) 25,056,976	219
South German States,	44,583	(1864) 8,524,460	191
North German Confederation,	160,369	(1864) 29,332,834	183
France,	209,437	(1861) 37,472,732	179
Switzerland,	15,716	(1860) 2,510,490	169
Austria,	240,367	(1864) 35,292,547	131
Denmark,	14,733	(1865) 1,717,802	118
Portugal and Islands,	37,972	(1863) 4,349,966	114
Turkey (Roumania, Servia and Montenegro, excluding Cyprus),	202,869	18,487,000	91
Spain,	195,598	(1864) 16,302,625	83
Greece, Cyclades and Ionian Islands,	19,350	(1867) 1,348,522	70
Russia in Europe and Poland,	2,050,314	(1864) 67,260,431	32
Sweden,	170,638	(1864) 4,070,061	24
Norway,	123,311	(1865) 1,701,478	14
Finland,	145,316	(1866) 1,844,008	12
Iceland and Faeroe Islands,	40,268	(1860) 75,909	1·8
Andorra,	149	12,000	
Helgoland, Gibraltar, and Malta,	148	163,683	
EUROPE,	3,933,073	294,346,069	75

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[1] England, area 58,320 sq. m.; pop. (1866) 21,210,020; pop. to sq. m. 364. Scotland, area 31,324 sq. m.; pop. (1866) 3,153,413; pop. to sq. m. 100. Ireland, area 32,513 sq. m.; pop. (1866) 5,571,971; pop. to sq. m. 171.

II.—ASIA.	*Area in sq. Miles.*	*Population.*	*No. to a sq. m.*
China proper,	1,560,000	450,000,000	288
Japan, Kurile and Loochoo Islands,	152,000	35,500,000?	233
India, British and Native States,	1,553,226	(1868) 191,401,988	123
Corea,	87,800	9,000,000?	102
Ceylon,	24,700	(1862) 2,079,881	84
East India Islands,[1]	799,000	27,165,000	34
Further India, (Burma, Siam, Annam, Cochin, China, and Malay Peninsula),	781,011	21,000,000	27
Turkey in Asia (Asia Minor, and Cyprus, Armenia, Kurdistan, Syria, and Arabistan),	672,006	16,463,000	24
Tibet,	652,000	11,000,000?	17
Afghanistan, and Herat,	258,500	4,000,000?	15
Beloochistan,	166,000	2,000,000?	12
Turkestan (Khiva, Bokhara, Kokand, etc.)	640,500	7,870,000	12
Persia,	562,380	5,000,000?	9
Manchuria,	492,380	3,000,000?	6
Arabia,	1,026,040	4,000,000?	4
Mongolia,	1,304,000	3,000,000?	2
Thian Shan, (Nan-lu and Pe-lu) Eastern Turkestan, Ili and Dzungaria,	596,600	1,000,000?	2
Russia in Asia, (Siberia and parts of Perm, Orenburg, and Caucasus),[2]	5,812,242	(1863) 9,748,017	1·6
Caspian Sea,	178,866		
Aral Sea,	26,9[illegible]7		
ASIA,	17,3[illegible]5,8[illegible]8	80[illegible],520,886	46

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[1] Java, area 51,336 sq. m.; pop. (1866) 14,[illegible]22,473, pop. to sq. m. 284. Sumatra, area 172,000 sq. m.; pop. 2,600,000; pop. to sq. m. 15. Borneo, area 282,000 sq. m., pop. 1,200,000; pop. to sq. m. 4.

[2] Caucasus in Europe and Asia, area 168,809 sq. m.; pop. 4,157,917; pop. to sq. m. 24. Siberia, area 5,582,915 sq. m.; pop. 4,625,629, pop. to sq. m. 0·8.

III.—AFRICA.	*Area in sq. Miles.*	*Population.*	*No. to a sq. m.*
Mohammedan States of Central Soudan,	631,000	38,800,000?	61
Western Soudan, from the Senegal to the Lower Niger with Upper Guinea, (Senegambia, Liberia, Dahome, and the British, Dutch, and Portuguese possessions.	818,500	38,500,000	46
Islands in the Atlantic Ocean, (Cape Verd Is. Ascension, St Helena, etc.,	2,720	115,063	42
Portuguese, Territory on the west coast, (Angola, Benguela, Mossamedes),	312,500	9,057,500?	29
Equatorial Regions,	1,522,000	43,000,000?	28
Tunis,	45,710	950,000	20
Madagascar,	232,300	4,450,000	19
Abyssinia,	158,400	3,000,000?	19
Eastern Africa (Gallas, Somauli),	1,436,200	26,700,000?	18
Islands in the Indian Ocean (except Madagascar),	5,676	999,300	17
Bassutu Land,	7,600	100,000?	13
Algeria,	258,000	(1867) 2,921,246	12
Marocco,	260,000	3,000,600	12
Egypt (Nubia, Kordofan),	659,080	7,465,000	11
Natal,	19,800	(1865) 158,621	8
South Africa, except settled parts,	890,000	5,640,000?	6
Cape Colony and British Kaffraria,	196,240	(1865) 577,734	3
Transvaal Republic,	109,535	(1868) 280,000	2·5
Tripoli, with Barca and Fezzan,	341,400	750,000	2
Sahara,	2,436,500	4,000,000?	1·6
Orange River, Republic,	48,000	50,000?	1
Portuguese Territory, east coast,	382,700	300,000?	0·8
Lakes of Africa and Deserts of the South,	780,000		
AFRICA,	11,556,861	190,814,464	16·5

IV. NORTH AMERICA (including Central America and the West India Islands).

	Area in sq. Miles.	*Population.*	*No. to a sq. m.*
District of Columbia, with Washington City,	10	75,080	7508
Bermudas,	24	(1863) 11,451	477
Massachusetts,	7,800	1,231,066	157
Rhode Island,	1,306	174,620	134
Connecticut,	4,750	460,147	98
New York,	47,000	3,884,520	82
New Jersey,	8,320	672,035	81
Pennsylvania,	46,000	2,906,115	63
Maryland,	11,124	687,049	62
Ohio,	39,964	2,339,502	59
Delaware,	2,120	112,216	53
West India Islands,	93,829	3,992,515	42
Prince Edward Island,	2,173	(1863) 84,356	40
Indiana,	33,809	1,350,812	40
New Hampshire,	9,280	326,073	35
Virginia,	38,352	1,261,397	33
Vermont,	10,212	315,098	31
Illinois,	55,410	1,711,951	30
Kentucky,	37,680	1,155,684	30
Tennessee,	45,600	1,109,982	24
South Carolina,	34,000	703,708	21
North Carolina,	50,704	994,121	19
Alabama,	50,722	964,201	19
Maine,	35,000	628,279	19
Georgia,	58,000	1,057,663	18
Missouri,	65,350	1,182,012	18
Nova Scotia,	18,671	(1861) 330,857	18
Mississipi,	47,156	792,205	17
Louisiana,	41,346	708,002	17
West Virginia,	23,000	393,234	17
Wisconsin,	53,924	778,714	14
Central America,	191,880	2,690,635	14
Upper Canada,	121,260	(1865) 1,655,022	13·6
Michigan,	56,451	756,890	13
Iowa,	55,045	674,948	12
Mexico,	773,150	(1866) 8,259,080	10·7
Arkansas,	52,198	501,130	9·6
New Brunswick,	27,037	(1861) 252,047	9
Lower Canada,	210,040	(1865) 1,226,849	5·8
Newfoundland with St Pierre Miquelon,	40,280	(1861) 126,174	3
Florida,	59,268	140,425	2·4
Minnesota,	83,531	191,755	2·3
Texas,	274,356	604,215	2·2
California,	188,981	393,534	2
Kansas,	81,318	115,395	1·4
British North America,	3,532,485	3,963,777	1·1
Oregon,	95,274	59,465	0.62
Nevada,	81,539	47,550	0.58
U. S. Territories, (Arizona, etc.)	1,148,429	465,901	0·40
British Columbia, and Vancouver Island,	213,000	(1863) 77,000	0·35
Alaska,	514,700	54,000	0·10
Labrador and Hudson's Bay,	2,900,000?	200,000?	0·07
Greenland,	760,000	10,000	0·01
Lakes,	150,000		
	9,050,414	53,475,889	5·9

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[1] The populations of the United States are for 1860; the total population of the United States in 1866 was 34,505,882, giving a density of 11·3.

V.—SOUTH AMERICA.

	Area in sq. Miles.	*Population.*	*No. to a sq. m.*
Chile,	132,624	(1865) 2,084,945	15·7
Paraguay,	126,352	1,337,439	10·6
U. S. of Columbia (New Granada),	357,178	2,900,000	8.1
Venezuela,	368,234	2,200,000	6
Ecuador,	220,000	1,300,000	6
Peru,	510,000	2,500,000	4·9
Bolivia,	535,800	(1858) 1,987,352	3·7
Brazil,	3,230,000	(1867) 11,780,000	3·6
Uruguay,	66,715	240,965	3·6
Argentine Republic,	826,827	1,466,000	1·7
British Guiana,	99,925	(1861) 162,026	1·6
Dutch Guiana,	62,846	(1865) 59,078	0·94
French Guiana,	35,080	(1864) 25,137	0·71
Falkland Islands,	4,740	(1865) 648	0·13
Patagonia, and Tierra del Fuego,	376,310	30,000	0·08
Galapagos, Aurora, and South Georgia Islands,	4,740	...	..
SOUTH AMERICA,	6,957,370	28,072,590	4·03

VI.—AUSTRALIA AND POLYNESIA (Areas from Behm by Debes).

	Area in sq. Miles.	*Population.*	*No. to a sq. m.*
Polynesia, except following Islands and Divisions,	72,990	1,492,000	20·5
Victoria,	88,450	(1865) 628,539	7·1
Tasmania,	26,215	(1867) 97,368	3·7
New Guinea,	274,520	1,000,000?	3·6
New Zealand,	106,259	(1866) 243,682	2·3
New South Wales,	308,560	(1866) 433,114	1 3
South Australia,	380,605	(1866) 175,000	0·46
Queensland,	668,260	(1866) 111,170	0 16
West Australia,	975,825	(1865) 20,260	0·04
Northern Territory,	523,530	12,000?	0·02
Mainland of Australia,	2,495,230	1,380,083	0·5
	3,425,214	4,213,133	1·2

VII.—QUARTERS OF THE GLOBE.

	Area in sq. Miles.	*Population.*	*No. to a sq. m.*
Europe,	3,933,073	294,346,069	75
Asia, and East India Islands,	17,345,808	803,320,886	46
Africa,	11,556,861	190,814,464	16·5
North and Central America, and West Indies,	9,050,444	53,475,889	5·9
South America,	6,957,370	28,072,590	4·03
Australia and Polynesia,	3,425,214	4,213,133	1·2
THE HABITABLE GLOBE,	52,268,770	1,374,243,031	26·2

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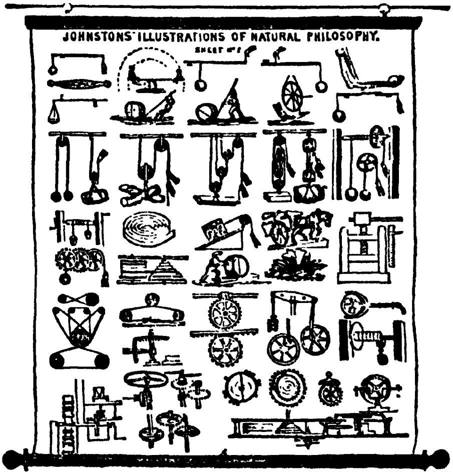
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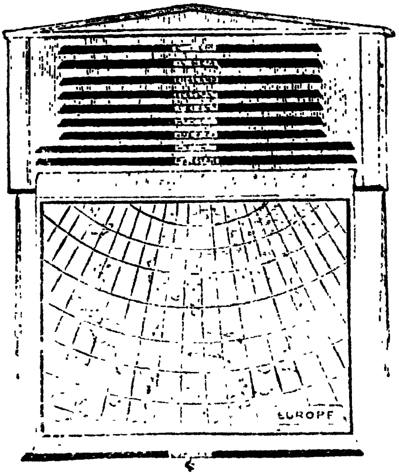

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